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MPPSC ASSISTANT PROFESSOR GEOLOGY
Edition March 2026
Published by :NODIA
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MRP ₹670.00

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Assistant Professor Exam-2025

Second Paper

Syllabus- Geology

UNIT-I: Geodynamics and Geomorphology

- **Origin of Earth, Geochronology, Seismology :** Seismic waves, intensity and isoseismic lines, Earthquake belts, Earthquake zones of India, cause of Earthquake. Internal structure of the Earth, Types of Volcanism and Causes of Volcanic eruptions. World distribution of volcanoes, paleo-magnetism.
- **Isostasy :** Development of the concept, Isostatic models and their Evidence. Geosynclines: Classification and evolution of Geosynclines, causes of subsidence and upliftment. Continental drift: Development of the concept, Taylor's and Wegner's theories of continental drift, Evidences of continental drift and polar wandering. Sea floor spreading.
- **Concept of plate tectonics :** Types of plate boundaries, features of convergent and divergent boundaries. Causes of Plate motion. Origin of the Himalayas.
- **Concept of Geomorphology :** principles and their significance. Cycle of erosion, Landslides, Soil creep. Fluvial Agency: Types of rivers, Valley development, Drainage Patterns and their significance. Erosional landforms and depositional landforms of streams. Glaciers: Types of Glaciers, Major features resulting from glacial erosion and glacial deposition.
- **Aeolian Agency :** Topographic effects of wind erosion. Landforms of aeolian deposition. Karst Topography: Important areas of Karst, Conditions essential for development of Karst, Characteristic features of Karst region. Marine erosion: Topographic features resulting from marine erosion and marine depositions. Morphometric Analysis of Terrain and its significance.

UNIT-II: Structural Geology

- **Rock Failure :** Mechanical principle of rock deformation, factor controlling behavior of material. Concept of stress and strain analysis in two and three dimensions. Progressive deformation. Mohr circles. Symmetry concept in deformation. Unconformities: types and recognition.
- **Geometry of folds surface :** Single and multi-layered, Super-imposed folding. Classification of folds. Types of folds. Recognition of folds. Effects of folds on outcrops.
- **Geometry of faults :** Classification and Types of faults, Slips, Separation. Recognition of faults. Cause of faulting.
- **Origin, kinds and their relation to other structures :** Fractures and joints, Lineation, Foliation, rock cleavage and schistosity.
- **Mechanics of folding and faulting :** Tectonic Fabrics, Magma Tectonics: Emplacement of Plutons. Origin of Ring Dykes and Cone sheets.

UNIT-III: Mineralogy and Geochemistry

- Atomic structure, mineralogical properties and mode of occurrence of the following:
- 1. Sulfides (AX, A_2X and AX_2 types), Oxides (XO, X_2O, XO_2, X_2O_3 and XY_2O_4 types) 2. Sulfates (anhydrous and hydrous) and Carbonates (calcite, aragonite and dolomite groups). Classification of silicate structures. Isomorphism, Polymorphism, Exsolution.
- Atomic structure, chemistry, physical and optical properties of the following rock forming mineral groups: Feldspar, Feldspathoid, Pyroxene, Amphibole, Mica and Zeolite.

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- Atomic structure, chemistry, physical and optical properties of the following rock forming mineral groups: Garnets, Olivine, Quartz and its varieties, Epidote, Chlorite, and Aluminosilicates (Kyanite, Sillimanite and Andalusite), Precious and Semi-precious Stones.
- Principles of optics: Double refraction, Optical properties of the minerals, Optical classification of minerals, Birefringence, Determination of Refractive Index.
- Geochemical classification of elements, Radioactive decay scheme of U-Pb, Rb-Sr, K-Ar and Sm-Nd. Laws of thermodynamics, Concept of geochemical cycle, Geochemical composition of the Earth.

UNIT-IV: Igneous and Metamorphic Petrology

- Origin of Magma. Factors affecting magma composition. Evolution of magma by differentiation and assimilation. Phase equilibria of monary (Silica), binary (mixed and eutectic) and ternary (Ab–An–Di), (Fo–Fa–Silica) silicate systems.
- Classification of igneous rocks including IUGS system. Reaction principle. Reaction series. Textures of igneous rocks and interpretation of crystallisation history. Layered igneous structures. Petrographic provinces.
- Origin of Granite: Magmatic and granitization processes. Petrogenesis, petrography and Indian occurrences of Basalt, Andesite, Carbonatite, Alkaline and Ultra Mafic rocks.
- Agents of metamorphism. Kinds of metamorphism. Types of metamorphism. Metamorphic differentiation. Structures and textures of metamorphic rocks. Concept of metamorphic zones.
- Metamorphic grades. Metamorphic facies. Metasomatism and their types. Origin and types of migmatites. Metamorphism of carbonates, pelites, mafic rocks. Charnockites and Khondalites.

UNIT-V: Sedimentology

- Processes of sedimentation. Fluid flow, origin of sediments. Modes of transport of sediments. Stoke's Law of sediments. Classification and nomenclature of the common sediments (rudites, arenites and argillites). Classification of sedimentary rocks.
- Origin, classification and significance of primary, secondary and organic sedimentary structures. Significance of palaeocurrent in quality assessment. Classification of sandstone, limestone and dolomite.
- Textures of sedimentary rocks and their genetic significance. Granulometric analyses of clastic particles. Lithification and diagenesis.
- Elements and types of depositional environments: Continental, transitional and marine environments. Evaporites and volcano-clastic sediments.
- Provenance and mineral stability. Concept and types of sedimentary provenance. Heavy minerals: their separation and utility in the provenance analyses.

UNIT-VI: Indian Stratigraphy and Palaeobiology

- Criteria for the stratigraphic classification and correlation. Litho-, Bio- and Chrono-stratigraphic units. Magneto-stratigraphy. Sequence stratigraphy. Geological time scale. Tectonic framework of India. Geological column of the Indian stratigraphy. Archaean (Azoic) history of India: Distribution and stratigraphy and economic importance of the Archaean of South India, Rajasthan, Jharkhand and Orissa.

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- Mesozoic history: Distribution and stratigraphy and fossil record of Triassic of Spiti, Jurassic of Cutch (Kachchh) and Cretaceous of South India. Bagh Beds. Lameta Beds. Deccan Traps. Palaeoclimate, classification, distribution, stratigraphy, economic importance and fossil record of the Gondwana Super Group. Cenozoic history: Tertiary of Assam, its economic importance. Siwaliks and its fossil record. K–T boundary problem.
- Modes of fossilization, uses of fossils, morphology, classification, evolution, and geological history of: Trilobites, Graptolites, Echinoids and Corals. Morphology, classification, evolution, and geological history of the Brachiopoda, Gastropoda, Lamellibranchia and Cephalopoda.
- Succession of the vertebrate life through the geological time. Micropalaeontology: Classification, application of microfossils in fossil fuel exploration, morphology and geological history of foraminifera. Concept of palaeobotany and palynology. Plant life through geological ages. Characteristic features of Gondwana flora.

UNIT-VII: Photogeology and Remote Sensing and Engineering Geology

- Introduction to aerial photography. Multi-spectral photography. Types of aerial photos: Geometric principles of photographs—relief and tilt displacement, vertical exaggeration and distortions. Taking measurements from aerial photographs: scales, distance, area and height.
- Preparation of photo-geologic maps. Mosaic controlling factors of aerial photograph. Scale, flight plan, area, purpose, time and season of photography. Introduction to overlap, sidelap, drift, crab, fiducial marks. Elements of interpretation of aerial photographs. Background knowledge, factors affecting aerial photographs.
- Types of electromagnetic radiation (EMR) energy used in remote sensing. Sensor platforms. Energy interaction with Earth surface and atmosphere. Reflectance of minerals, vegetation, rock and water. Scattering active and passive sensors imaging. Multi-spectral scanners (MSS), SLAR, SAR, LISS cameras. Thermal infra-red line scanners (TIRLS). Near infra-red (NIR), microwave (radar) imagery. Introduction to image processing, continuous image processing, discrete image processing system.
- Application of photo geology and remote sensing in the study of geomorphology, lithology and structural features and hydrogeology studies. Geographic Information System (GIS) and its applications.
- Importance of geology in civil engineering. Engineering properties of rocks. Dam and reservoir: Types of dams, geological consideration for the selection of a dam site. Geological consideration in major engineering projects: construction of tunnels, highways, bridges and canals. Lining of tunnel.

UNIT-VIII: Economic Geology and Fuel Geology

- Relation of magma to mineral deposits. Geological thermometers. Ore genesis. Control of ore deposits. Paragenesis and zoning in mineral deposits. Classification of processes of mineral deposits. Processes of mineral deposits: Magmatic concentration, sublimation, pegmatite, contact metasomatism, hydrothermal and metamorphic volcano-genetic deposits, carbonatites.
- Processes of mineral deposits: Sedimentary, placer, residual, evaporation and oxidation & supergene sulphide enrichment. Ore microscopy: Textures and structures of ores. Origin, mode of occurrence, association, uses and Indian occurrences of the ores of iron,

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manganese, chromium, nickel, copper, lead, zinc, aluminium, tin, tungsten, titanium, beryllium, molybdenum, gold and silver.

- Origin, mode of occurrence, association, uses and Indian occurrences of the non-metallic minerals: Mica, asbestos, barites, graphite, gypsum, ochre, precious and semi-precious minerals. Minerals used in fertilizers and cement industries.
- Mineral economics: Significance of minerals in national economy, national mineral policy, fundamentals of mineral concession rules of India, strategic, critical and essential minerals.
- Origin of coal. Physico-chemical characterization, rank and varieties of coal. Macroscopic ingredients and microscope constituents (maceral, lithotypes and microlithotypes). Origin, migration and accumulation (oil traps) of petroleum and natural gas. Position of oil and natural gas in India. Atomic minerals: mode of occurrence, association and distribution in India. Methods of prospecting, productive horizons in India, nuclear power stations of the country and future prospects.

UNIT-IX: Mineral Exploration, Mining, Mineral Dressing and Hydrogeology

- Geological exploration: Mode of occurrence of commercial grade deposits of ores. Methods of geological exploration: exploratory grids, pits, trenches, core sampling, well logging in evaluation of deposits. Drilling technology for exploration. Sampling methods. Assaying by channel sampling and placer sampling, underground mining sampling. Calculation of ore reserves. Classification of reserves. UNF classification.
- Classification and principles of geophysical methods: Electrical method, magnetic methods, gravity methods, seismic methods in mineral exploration. Geochemical exploration: Geochemical cycle mobility of elements, path finder elements, mode of occurrence of trace elements, primary and secondary dispersion, syngenetic and epigenetic diffusion. Sampling technique for geochemical exploration. Geobotanical exploration.
- Mining terminology. Percussion and rotary drilling methods. Classification of mining methods. Alluvial mining and open-cast mining. Underground mining (other than coal mining): stoping methods. Coal mining methods. Haulage and winding.
- Mineral dressing: Physical properties of minerals utilized in mineral dressing. Crushers: primary and secondary crushers. Grinding mills. Industrial screening. Gravity separation. Heavy medium separation. Magnetic separation. Froth flotation technique of separation of sulphide ores. Mining and metallurgy in ancient India: Zawar Mines Rajasthan.
- Hydrogeology: Distribution of water – surface and sub-surface. Hydrological cycle. Groundwater: origin, importance, occurrences and subsurface reservoirs. Hydrological properties of rocks, aquifers and their classification. Groundwater flow, Darcy's law. Groundwater quality: physical, chemical and biological characteristics. Water harvesting. Wetland management. Concept of watershed management. Natural and artificial recharge of groundwater.

UNIT-X: Geology, Mineral Resources, Hydrogeology and Geoheritage of Madhya Pradesh

- Geology of Madhya Pradesh: Various stratigraphic units of Madhya Pradesh, tectonic features of Narmada and Tapti.
- Mineral wealth of Madhya Pradesh, important mines of Madhya Pradesh, mineral based industries in Madhya Pradesh.
- Groundwater provinces of Madhya Pradesh, natural waterbodies and manmade ancient waterbodies of Madhya Pradesh.

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- Ramsar Sites (Wetland) of Madhya Pradesh.
- Geodiversity of Madhya Pradesh: Rock monuments, geoheritage sites and geotourism in Madhya Pradesh, prospects of geoparks in Madhya Pradesh, geoarchaeological sites of Madhya Pradesh: Bhimbetka rock shelters and rock art, Bagh caves, Dhar district. Fossils of Narmada valley and fossil parks of Madhya Pradesh.

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CHAPTER 01
Geodynamics and Geomorphology

1. Which of the following is a primary type of seismic wave that travels through the Earth's interior and involves compression and rarefaction of the material?
(A) S-waves
(B) P-waves
(C) L-waves
(D) Rayleigh waves

2. What is the primary subject of study in Geochronology?
(A) Determining the time sequence of events in Earth's history
(B) Investigating the Earth's local magnetic field history
(C) Analyzing the precise chemical composition of rocks
(D) Exploring the surface formation of diverse landforms

3. Consider the following statements regarding the internal structure of the Earth:
Statement I : The outer core is believed to be in a liquid state.
Statement II : The inner core is believed to be in a solid state despite higher temperatures due to immense pressure.
Which of the statements is/are correct?
(A) Only Statement I
(B) Only Statement II
(C) Both Statement I and Statement II
(D) Neither Statement I nor Statement II

4. The following question consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Examine these two statements carefully and select the correct answer using the options given below:
Assertion (A) : S-waves cannot pass through the Earth's outer core.
Reason (R) : The Earth's outer core is in a liquid state, and shear waves cannot propagate through liquids.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

5. Which of the following statements about the causes of earthquakes is incorrect?
(A) Earthquakes are often caused by the sudden release of energy along a fault line.
(B) Volcanic activity can trigger seismic events.
(C) All earthquakes exclusively occur at plate boundaries.
(D) Human activities such as reservoir-induced seismicity can cause minor earthquakes.

6. A line connecting all points on the Earth's surface where the intensity of an earthquake is the same is known as an:
(A) Isobar
(B) Isoseismic line
(C) Isohyet
(D) Isotherm

7. Match List I with List II regarding the internal structure of the Earth:
List I: (Layer)
P. Crust
Q. Mantle
R. Outer Core
S. Inner Core
List II: (Primary Composition/State)
1. Liquid Iron-Nickel
2. Solid Iron-Nickel
3. Silicate rocks (SiMa)
4. Silicate rocks (SiAl)
(A) P-4, Q-3, R-1, S-2
(B) P-3, Q-4, R-2, S-1
(C) P-4, Q-1, R-3, S-2
(D) P-1, Q-2, R-4, S-3

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8. The phenomenon of paleo-magnetism provides strong evidence for which of the following geological theories?
(A) Sea floor spreading and Plate Tectonics
(B) Isostasy and crustal equilibrium
(C) Geosynclinal theory and sedimentation
(D) Cycle of Erosion and landscape evolution

9. What is the most appropriate definition of a 'shield volcano'?
(A) A steep conical volcano built by viscous lava flows and pyroclastic material.
(B) A volcanic landform resulting from a violent eruption that collapses the summit.
(C) A broad, gently sloping volcano built from fluid basaltic lava flows.
(D) A linear volcanic vent through which lava erupts, usually without explosive activity.

10. The concept of isostasy primarily deals with the:
(A) Equilibrium between the lithosphere and asthenosphere
(B) Bending and complex faulting of crustal layers
(C) The global process of structural mountain building
(D) Erosional and depositional activities of rivers

11. Consider the following statements about volcanism:
1. The 'Ring of Fire' is a major belt of volcanoes rimming the Pacific Ocean.
2. Volcanic eruptions are exclusively explosive in nature.
3. The cause of volcanism is related to the movement and interaction of tectonic plates.

Which of the above statements is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

12. Which of the following is NOT a major earthquake belt of the world?
(A) The Circum-Pacific Belt
(B) The Central Siberian Shield
(C) The Mid-Atlantic Ridge
(D) The Alpine-Himalayan Belt

13. The theory of isostasy was significantly developed by which two geologists who proposed different models?
(A) Wegener and Taylor
(B) Davis and Penck
(C) Airy and Pratt
(D) Hess and Dietz

14. According to the isostatic model proposed by Airy, mountains have:
(A) Higher density rocks compared to the surrounding crust.
(B) Lower density rocks and uniform depth of compensation.
(C) Uniform density but varying thickness floating on a fluid substratum.
(D) Roots of lighter material extending deep into the denser substratum.

15. The following question consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Examine these two statements carefully and select the correct answer using the options given below:
Assertion (A) : The Himalayan range is located in a high-risk earthquake zone.
Reason (R) : The Himalayas are situated at a convergent plate boundary where the Indian plate is colliding with the Eurasian plate.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

16. What is the primary characteristic of a geosyncline?
(A) A stable, rigid, and well-defined tectonic part of the continental crust.
(B) A shallow marine depression that subsides as it accumulates sediment.
(C) A prominent mountain range formed through extensive volcanic activity.
(D) A flat, low-lying coastal plain created by sustained river deposition.

17. Which of the following is considered the most significant evidence for sea-floor spreading?
(A) The similar shapes of coastlines on opposite sides of the Atlantic.

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(B) The pattern of magnetic anomalies recorded in the rocks of the ocean floor.
(C) The presence of glacial deposits in tropical regions.
(D) The existence of deep-sea trenches.

18. Consider the following theories related to the development of Earth's crustal features:
1. Theory of Continental Drift (Wegener)
2. Theory of Sea Floor Spreading (Hess)
3. Theory of Plate Tectonics
4. Concept of Isostasy (Airy & Pratt)

What is the correct chronological order of their development?
(A) 4, 1, 2, 3
(B) 1, 4, 2, 3
(C) 4, 2, 1, 3
(D) 1, 2, 4, 3

19. According to Alfred Wegener's theory of continental drift, what was the name of the supercontinent that existed around 200 million years ago?
(A) Laurasia
(B) Gondwanaland
(C) Pangaea
(D) Rodinia

20. Which feature is characteristically found at a divergent plate boundary?
(A) Mountain ranges like the Himalayas
(B) Subduction zones and volcanic arcs
(C) Transform faults like the San Andreas Fault
(D) Mid-oceanic ridges

21. The upliftment phase in the evolution of a geosyncline is primarily associated with which process?
(A) Continuous sedimentation and subsidence.
(B) Isostatic adjustment due to erosion.
(C) Orogenic (mountain-building) forces.
(D) Widespread volcanic eruptions.

22. Match List I with List II regarding plate boundaries:
List I: (Type of Boundary)
P. Convergent (Oceanic-Continental)
Q. Convergent (Continental-Continental)
R. Divergent
S. Transform
List II: (Associated Feature)
1. Mid-Atlantic Ridge
2. San Andreas Fault
3. Himalayan Mountains
4. Andes Mountains

(A) P-1, Q-2, R-3, S-4
(B) P-4, Q-3, R-1, S-2
(C) P-3, Q-4, R-2, S-1
(D) P-4, Q-1, R-2, S-3

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23. Which of the following was NOT used by Wegener as evidence for his theory of continental drift?
(A) The fit of the continents
(B) Fossil evidence (e.g., Glossopteris)
(C) Paleoclimatic evidence (e.g., glacial deposits)
(D) Paleomagnetic stripes on the ocean floor

24. The concept of 'polar wandering' suggests that:
(A) The continents have moved relative to the fixed magnetic poles.
(B) The Earth's magnetic poles have physically moved over geological time.
(C) The Earth's axis of rotation has changed its tilt.
(D) The magnetic field of the Earth periodically reverses.

25. What is the primary driving force behind the movement of tectonic plates?
(A) Gravitational pull from the moon and sun.
(B) The rotation of the Earth (Coriolis effect).
(C) Convection currents within the Earth's mantle.
(D) The weight of oceanic and continental crust.

26. The concept of geomorphology is best described as:
(A) The scientific study of landforms and the processes that create and shape them.
(B) The study of the Earth's internal structure.
(C) The study of historical climates and their impact on geography.
(D) The classification of rocks and minerals.

27. Consider the following statements about plate boundaries:
Statement I : New oceanic crust is created at convergent boundaries.
Statement II : Old oceanic crust is destroyed at divergent boundaries.

Which of the statements is/are correct?
(A) Only Statement I
(B) Only Statement II
(C) Both Statement I and Statement II
(D) Neither Statement I nor Statement II

28. Consider the following statements about the origin of the Himalayas:
1. They are an example of fold mountains.
2. Their formation is a result of the collision between the Indian and Eurasian plates.
3. The process of their formation is largely complete and the mountains are no longer rising.

Which of the above statements is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

29. The 'Cycle of Erosion' model, which describes the sequential development of landforms through stages of youth, maturity, and old age, was famously proposed by:
(A) G.K. Gilbert
(B) Walther Penck
(C) William Morris Davis
(D) John Wesley Powell

30. The following question consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Examine these two statements carefully and select the correct answer using the options given below:
Assertion (A) : Isostatic uplift can occur in regions that were previously covered by large ice sheets.
Reason (R) : The melting of massive ice sheets removes a significant weight from the crust, causing it to rebound slowly.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

31. Which of the following processes is an example of slow mass wasting?
(A) Soil creep
(B) Landslide
(C) Mudflow
(D) Rockfall

32. What is the primary significance of studying drainage patterns?
(A) To determine the age of a river.
(B) To understand the underlying geological structure and rock type.
(C) To measure the water discharge of a stream.
(D) To predict the exact location of future floods.

33. An incised meander is a feature that indicates:
(A) A river is in its old age stage.
(B) The river has experienced a period of rapid uplift and downcutting.
(C) The river is flowing over a very soft and uniform rock bed.
(D) The river is heavily loaded with sediment and is aggrading its bed.

34. Which of the following is a depositional landform created by a stream?
(A) Alluvial fan
(B) Gorge
(C) Pothole
(D) Waterfall

35. A dendritic drainage pattern is typically expected to develop on which type of underlying geology?
(A) A region with folded rock structures with alternating layers of resistance.
(B) A volcanic cone with radial fractures.
(C) Massive igneous rocks or uniform, flat-lying sedimentary rocks.
(D) A complexly faulted and jointed tectonic landscape.

36. Which of the following is NOT a type of glacier?
(A) Ice Sheet
(B) Piedmont Glacier
(C) Cirque Glacier
(D) Sea Ice

37. A sharp, knife-edge ridge formed between two adjacent cirques is called:
(A) A horn
(B) A moraine
(C) An arête
(D) An esker

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38. Which of the following is a column feature resulting from glaciation?
(A) U-shaped valley
(B) Drumlin
(C) Cirque
(D) Roche moutonnée

39. The process of wind erosion where loose particles are removed and transported is known as:
(A) Abrasion
(B) Attrition
(C) Saltation
(D) Deflation

40. Crescent-shaped dunes with horns pointing downwind are known as:
(A) Barchans
(B) Seifs
(C) Parabolic dunes
(D) Star dunes

41. Which condition is most essential for the development of Karst topography?
(A) Presence of granite bedrock
(B) An arid climate with very little rainfall
(C) Presence of soluble limestone at or near the surface
(D) A landscape dominated exclusively by glacial till

42. Sinkholes, stalactites, and stalagmites are characteristic features of which type of landscape?
(A) Karst
(B) Aeolian
(C) Fluvial
(D) Glacial

43. A sea cliff is a landform created by:
(A) Marine deposition
(B) Aeolian deposition
(C) Fluvial erosion
(D) Marine erosion

44. A ridge of sand that connects an island to the mainland or to another island is called a:
(A) Spit
(B) Tombolo
(C) Baymouth bar
(D) Barrier island

45. Match List I with List II regarding landforms and their geomorphic agents:
List I: (Landform)
P. Oxbow Lake
Q. Moraine
R. Barchan
S. Stalactite
List II: (Geomorphic Agent)
1. Wind
2. Groundwater/Karst
3. River
4. Glacier
(A) P-3, Q-4, R-1, S-2
(B) P-4, Q-3, R-2, S-1
(C) P-3, Q-1, R-4, S-2
(D) P-1, Q-2, R-3, S-4

46. What does morphometric analysis of a terrain primarily involve?
(A) The chemical analysis of soil and rock samples.
(B) The study of past climates through landscape evidence.
(C) The mapping of geological faults and fractures.
(D) The quantitative measurement and mathematical analysis of landform shapes.

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47. In the context of the origin of Earth, the nebular hypothesis primarily suggests that the solar system formed from:
(A) A large, rotating cloud of gas and dust.
(B) The collision of two pre-existing stars.
(C) Material ejected from the Sun.
(D) The capture of interstellar planets by the Sun's gravity.

48. Consider the following statements regarding seismic waves:
Statement I : P-waves are longitudinal waves, and S-waves are transverse waves.
Statement II : S-waves travel faster than P-waves.
Which of the statements is/are correct?
(A) Only Statement I
(B) Only Statement II
(C) Both Statement I and Statement II
(D) Neither Statement I nor Statement II

49. Which one of the following is NOT a direct cause of earthquakes?

(A) Tectonic plate movement
(B) Coriolis force
(C) Volcanic eruption
(D) Isostatic adjustment

50. Consider the following statements about isostatic models:
1. Airy's model assumes varying densities and a uniform depth of compensation.
2. Pratt's model assumes uniform density but varying thickness (root formation).
3. Both models attempt to explain the gravitational equilibrium of crustal blocks.

Which of the above statements is/are correct?
(A) 3 only
(B) 1 and 2 only
(C) 1 and 3 only
(D) 2 and 3 only

51. The process of subsidence in a geosyncline is primarily driven by:
(A) The collision of two continental plates.
(B) The formation of a mid-oceanic ridge.
(C) The weight of accumulating sediments.
(D) The erosion of surrounding highlands.

52. F.B. Taylor's theory of continental drift, a precursor to Wegener's, primarily attributed the movement of continents to:
(A) Mantle convection
(B) The Earth's rotation
(C) Isostatic imbalance
(D) Tidal forces from the Moon

53. A feature such as a volcanic island arc is typically associated with which type of plate boundary?
(A) Oceanic-Oceanic divergent
(B) Oceanic-Continental convergent
(C) Oceanic-Oceanic convergent
(D) Continental-Continental convergent

54. The principle of geomorphology stating The same physical processes and laws that operate today operated throughout geologic time" is known as:
(A) Catastrophism
(B) Uniformitarianism
(C) Tectonic Pre-design
(D) Geomorphic Threshold

55. The following question consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Examine these two statements carefully and select the correct answer using the options given below:
Assertion (A) : A trellis drainage pattern often develops in regions of folded sedimentary rocks.
Reason (R) : The main streams follow the valleys cut in weaker rock, and tributaries join at near right angles, flowing down the slopes of the more resistant ridges.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

56. The slow, downslope movement of soil and regolith, often indicated by tilted trees and fences, is called:
(A) Soil creep
(B) Solifluction
(C) Rockslide
(D) Debris flow

57. A river valley in its youthful stage is typically characterized by:
(A) A wide floodplain and numerous meanders.
(B) Oxbow lakes and natural levees.
(C) A V-shaped cross-profile and rapid down cutting.
(D) A gentle gradient and slow flow velocity.

58. What is a fjord?
(A) A deep, U-shaped glacial trough that has been drowned by the sea.
(B) A river valley flooded by the sea.
(C) A volcanic crater filled with water.
(D) A lagoon separated from the open sea by a sandbar.

59. Loess is a depositional landform primarily associated with which geomorphic agency?
(A) Glacial
(B) Fluvial
(C) Marine
(D) Aeolian

60. The development of caves, dolines, and poljes is characteristic of which geological process?

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(A) Glacial scouring
(B) Subsurface dissolution in Karst regions
(C) Volcanic extrusion
(D) Fluvial incision

61. Which of the following features is created by marine deposition?
(A) Sea arch
(B) Wave-cut platform
(C) Spit
(D) Sea stack

62. Relief ratio, drainage density, and stream frequency are parameters used in:
(A) Seismology
(B) Paleomagnetism
(C) Geochronology
(D) Morphometric analysis

63. Which type of volcanism is characterized by eruptions from long, linear cracks in the crust, leading to the formation of large basalt plateaus?
(A) Fissure eruption
(B) Stratovolcano eruption
(C) Shield volcano eruption
(D) Caldera collapse

64. The 'shadow zone' of an earthquake is an area where:
(A) Only P-waves are received.
(B) Neither P-waves nor S-waves are received directly.
(C) Only S-waves are received.
(D) Surface waves are the strongest.

65. Consider the following stages of the Davisian Cycle of Erosion:
1. Old Age
2. Youth
3. Maturity

What is the correct chronological sequence?
(A) 1, 2, 3
(B) 2, 3, 1
(C) 3, 2, 1
(D) 2, 1, 3

66. What does the term 'paleo-magnetism' refer to?
(A) The record of the Earth's magnetic field preserved in rocks.
(B) The study of the Earth's present-day magnetic field.
(C) The magnetic properties of living organisms.
(D) The influence of magnetism on landform development.

67. Which of the following is an example of an orogenic force in the context of geosynclines?
(A) Isostatic rebound after deglaciation.
(B) Subsidence due to sediment loading.
(C) Compressional stress leading to folding and faulting.
(D) Erosion by wind and water.

68. The primary difference between Taylor's and Wegener's continental drift theories lies in the:
(A) Proposed supercontinent.
(B) Evidences cited.
(C) Time period of continental breakup.
(D) Proposed mechanism or driving force.

69. Deep-sea trenches are most commonly found along:
(A) Divergent plate boundaries.
(B) Transform plate boundaries.
(C) Subduction zones at convergent boundaries.
(D) The center of continental plates.

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70. Match List I with List II regarding drainage patterns and their descriptions:
List I: (Drainage Pattern)
P. Dendritic
Q. Trellis
R. Radial
S. Centripetal
List II: (Description)
1. Streams flow from a central high point, like a volcano.
2. Streams flow towards a central depression or basin.
3. A tree-like pattern on uniform bedrock.
4. Parallel main streams with short tributaries at right angles, typical of folded terrain.
(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-1, R-4, S-2
(C) P-3, Q-4, R-1, S-2
(D) P-4, Q-3, R-2, S-1

71. A roche moutonnée is a landform that shows evidence of:
(A) Fluvial deposition on one side and erosion on the other.
(B) Wind scouring on the windward side and

deposition on the leeward side.
(C) Wave erosion on the seaward side and deposition on the landward side.
(D) Glacial abrasion on the upstream side and plucking on the downstream side.

72. What are yardangs?
(A) Ridges of rock, oriented parallel to the prevailing wind, separated by grooves.
(B) Deposits of wind-blown silt.
(C) Large, pyramid-shaped sand dunes.
(D) Pillars of rock formed by marine erosion.

73. The term 'hanging valley' is associated with which type of landscape?
(A) Karst
(B) Fluvial
(C) Glacial
(D) Aeolian

74. Consider the following case: A coastal area is characterized by a prominent cliff, a flat rocky platform at its base visible at low tide, and several isolated rock pillars offshore. These features are the result of:
(A) Marine erosion and wave action.
(B) Tectonic uplift and subduction.
(C) Volcanic activity and lava flows.
(D) Glacial scouring and deposition.

75. Consider the following statements regarding the concept of sea floor spreading:
1. It was proposed by Harry Hess.
2. It suggests that new oceanic crust forms at mid-ocean ridges and moves outwards.
3. It failed to explain the existence of deep-sea trenches.

Which of the above statements is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

76. The intensity of an earthquake is measured using the:
(A) Richter Scale
(B) Modified Mercalli Scale
(C) Seismograph Scale
(D) Moment Magnitude Scale

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77. The distribution of volcanoes and earthquakes is strongly correlated with:
(A) The location of major river systems.
(B) The distribution of ancient shield areas.
(C) The boundaries of tectonic plates.
(D) Latitudinal and longitudinal lines.

78. The concept that lighter continental crust floats" on denser mantle material is a fundamental principle of:
(A) Geochronology
(B) Plate Tectonics
(C) Paleo-magnetism
(D) Isostasy

79. Which statement best describes the evolution of a geosyncline?
(A) A basin subjected to compression and uplift after prolonged sedimentation.
(B) A basin that deepens indefinitely until it is filled by the open ocean.
(C) A basin uplifted isostatically without deformation of sedimentary layers.
(D) A basin where volcanic material creates a stable and high plateau.

80. The following question consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Examine these two statements carefully and select the correct answer using the options given below:
Assertion (A) : The coastlines of South America and Africa appear to fit together like a puzzle.
Reason (R) : These continents were once part of a single supercontinent, Pangaea, before they drifted apart.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

81. Which of the following is a type of plate boundary where two plates slide past each other horizontally?
(A) Convergent boundary
(B) Transform boundary
(C) Divergent boundary
(D) Subduction boundary

82. The 'base level of erosion', a key concept in the cycle of erosion, refers to:
(A) The lowest level to which a stream can erode its valley.
(B) The highest point in a drainage basin.
(C) The average elevation of a landscape in its mature stage.
(D) The depth of the water table.

83. Potholes in a riverbed are formed by which erosional process?
(A) Hydraulic action
(B) Attrition
(C) Abrasion or corrasion
(D) Solution or corrosion

84. A sinuous ridge of sand and gravel deposited by a meltwater stream flowing in a tunnel under a glacier is called:
(A) A moraine
(B) A drumlin
(C) A kame
(D) An esker

85. Which of the following is NOT a landform of aeolian deposition?
(A) Sand dune
(B) Loess
(C) Ventifact
(D) Ripples

86. For Karst topography to develop, besides soluble rock, what is another crucial condition?
(A) Impermeable rock layers above the soluble rock.
(B) Ample groundwater and a system of joints and fractures in the rock.
(C) A very low water table.
(D) An extremely arid climate.

87. A wave-cut platform is an erosional feature found:
(A) At the top of a sea cliff.
(B) In the deep ocean basin.
(C) Connecting an island to the mainland.
(D) At the base of a sea cliff.

88. The significance of morphometric analysis in geomorphology lies in its ability to:
(A) Objectively compare different landscapes and infer the processes acting upon them.
(B) Provide a qualitative description of landscapes.
(C) Date the absolute age of landforms.
(D) Determine the chemical composition of landforms.

89. According to the elastic rebound theory, an earthquake is caused by:
(A) The release of progressively stored strain in rocks
(B) The slow, continuous creep of tectonic plates
(C) The collapse of massive underground caverns
(D) The sudden atmospheric impact of a large meteorite

90. The most volcanically active regions on Earth are typically found at:
(A) Divergent and convergent plate boundaries.
(B) The centers of large continental masses.
(C) Stable continental shelves.
(D) Areas of intense glacial activity.

91. Pratt's model of isostasy differs from Airy's in that it proposes:
(A) Crustal blocks have varying densities and float at different levels.
(B) Crustal blocks have uniform density but different thicknesses (roots).
(C) All crustal blocks are rigid and do not float.
(D) Crustal blocks have varying densities but a uniform depth of compensation.

92. What is the final stage in the life cycle of a geosyncline, after the orogenic phase?
(A) Lithogenesis (sedimentation)
(B) Glyptogenesis (erosion and leveling)
(C) Taphrogenesis (block faulting)
(D) Continued subsidence

93. The concept of sea floor spreading" was a crucial stepping stone to the development of:
(A) The theory of isostasy.
(B) The cycle of erosion.
(C) The theory of plate tectonics.
(D) The nebular hypothesis.

94. The San Andreas Fault in California is a classic example of a:
(A) Subduction zone

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(B) Mid-ocean ridge
(C) Continental collision zone
(D) Transform fault boundary

95. Match List I with List II regarding glacial features:
List I: (Glacial Feature)
P. Esker
Q. Arête
R. Cirque
S. Drumlin
List II: (Type)
1. Erosional (Ridge)
2. Depositional (Ridge)
3. Depositional (Mound)
4. Erosional (Hollow)
(A) P-2, Q-1, R-4, S-3
(B) P-3, Q-4, R-1, S-2
(C) P-2, Q-3, R-4, S-1
(D) P-1, Q-2, R-3, S-4

96. A river delta is a landform created at the:
(A) Source of a river in the mountains.
(B) Point where a river enters a standing body of water like a lake or sea.
(C) Mid-section of a river with a wide floodplain.
(D) Point where a tributary joins a main river.

97. An isolated, steep-sided hill of rock rising abruptly from a flat plain, common in tropical regions, is known as an:
(A) Esker
(B) Inselberg
(C) Yardang
(D) Drumlin

98. Which of the following is a key characteristic of a landscape in the 'mature' stage of the Davisian cycle?
(A) Maximum relief, well-integrated drainage, and the beginning of floodplain development.
(B) Poorly defined drainage and V-shaped valleys.
(C) A vast, low-lying peneplain with sluggish streams.
(D) Dominated by waterfalls and rapids.

99. The deposition of fine, wind-blown silt, which can form extensive and fertile plains, is known as:
(A) Alluvium
(B) Till
(C) Loess
(D) Colluvium

100. Consider the following statements about Karst landscapes:
1. They are primarily formed by the mechanical weathering of sandstone.
2. Surface drainage is often absent due to water disappearing into underground channels.
3. The name originates from a region in Slovenia.
Which of the above statements is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

101. A spit that grows across the mouth of a bay, sometimes completely enclosing it, is called a:
(A) Tombolo
(B) Headland
(C) Baymouth bar
(D) Barrier island

102. Which parameter in morphometric analysis measures the total length of all streams in a basin divided by the area of the basin?
(A) Stream frequency
(B) Drainage density
(C) Bifurcation ratio
(D) Relief ratio

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103. The point on the Earth's surface directly above the focus of an earthquake is the:
(A) Hypocenter
(B) Seismic center
(C) Isoseismic point
(D) Epicenter

104. Which one of the following is NOT a type of volcanism based on eruptive style?
(A) Isostatic
(B) Hawaiian
(C) Strombolian
(D) Plinian

105. Evidence for isostatic adjustment can be seen in:
(A) The symmetrical magnetic stripes on the ocean floor.

(B) The formation of fold mountains like the Alps.
(C) The rising coastlines of Scandinavia after the last ice age.
(D) The occurrence of deep-focus earthquakes.

106. The concept of a geosyncline was originally developed to explain the formation of:
(A) Folded mountain belts
(B) Rift valleys
(C) Volcanic islands
(D) Ocean basins

107. The 'jigsaw fit' evidence for continental drift refers to the complementary shapes of the coastlines of:
(A) North America and Asia
(B) Australia and Antarctica
(C) India and Africa
(D) South America and Africa

108. The main cause of plate motion, according to the theory of plate tectonics, is thought to be:
(A) Tidal forces
(B) Mantle convection
(C) Earth's rotation
(D) Gravitational pull of the Sun

109. The principle of geomorphology that states Geomorphic processes leave their distinctive imprint upon landforms" implies that:
(A) All landforms look the same regardless of the process.
(B) Landforms do not change once formed.
(C) One can infer the process by studying the shape of the landform.
(D) Only catastrophic events create recognizable landforms.

110. The following question consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Examine these two statements carefully and select the correct answer using the options given below:
Assertion (A) : The Pacific Ring of Fire is a zone of high seismic and volcanic activity.
Reason (R) : It corresponds to the stable, interior part of the large Pacific Plate.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

111. Natural levees are depositional features associated with:
(A) Rivers
(B) Glaciers
(C) Wind
(D) Coastlines

112. A cirque is an erosional feature best described as:
(A) A V-shaped valley cut by a river.
(B) An amphitheater-shaped hollow at a glacial valley head.
(C) A deep crack in a mountain glacier.
(D) A sharp ridge between two valleys.

113. Longitudinal dunes, also known as seifs, are oriented:
(A) Perpendicular to the prevailing wind direction.
(B) Parallel to the prevailing wind direction.
(C) In a star shape due to variable wind directions.
(D) In a crescent shape with horns pointing downwind.

114. The primary erosional process in Karst regions is:
(A) Solution (dissolution)
(B) Abrasion
(C) Deflation
(D) Plucking

115. Consider the following events related to continental drift theory:
1. Alfred Wegener publishes The Origin of Continents and Oceans".
2. Harry Hess proposes the concept of sea-floor spreading.
3. The supercontinent Pangaea begins to break apart.
4. J. Tuzo Wilson introduces the concept of transform faults.

What is the correct chronological order of these events?
(A) 3, 1, 2, 4
(B) 1, 3, 2, 4
(C) 3, 2, 1, 4

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(D) 1, 2, 3, 4

116. Which of the following coastal features is formed by erosion?
(A) Beach
(B) Tombolo
(C) Barrier island
(D) Sea stack

117. The bifurcation ratio in morphometric analysis describes the relationship between:
(A) The length and width of a drainage basin.
(B) The basin relief and basin length.
(C) Stream segments of consecutive orders.
(D) The channel gradient and stream velocity.

118. The Mohorovičić discontinuity (Moho) marks the boundary between:
(A) The inner and outer core.
(B) The crust and the mantle.
(C) The mantle and the core.
(D) The lithosphere and the asthenosphere.

119. A volcano that is currently erupting or has shown signs of unrest is classified as:
(A) Dormant
(B) Extinct
(C) Shield
(D) Active

120. Taylor's theory of continental drift was largely dismissed because:
(A) The proposed tidal forces were shown to be far too weak.
(B) It could not explain the fit of the continents.
(C) It lacked fossil evidence.
(D) It was published after Wegener's more comprehensive theory.

121. The process of one tectonic plate sliding beneath another is called:
(A) Spreading
(B) Rifting
(C) Subduction
(D) Transformation

122. A landscape dominated by a vast, gently undulating plain of low relief, considered the end product of the fluvial cycle of erosion, is a:
(A) Peneplain
(B) Pediplain
(C) Structural plain
(D) Outwash plain

123. A meander that has been cut off from the main river channel forms an:
(A) Alluvial fan
(B) Delta
(C) Natural levee
(D) Oxbow lake

124. Which of the following is a major feature resulting from continental glaciation (ice sheets)?
(A) Deep U-shaped valleys
(B) Large-scale scouring of the landscape and deposition of till sheets
(C) Arêtes and horns
(D) Incised meanders

125. Match List I with List II regarding geological terms:
List I: (Term)
P. Pangaea
Q. Panthalassa
R. Tethys Sea
S. Laurasia
List II: (Definition)
1. The northern supercontinent after the initial breakup.
2. The super-ocean surrounding the supercontinent.
3. The sea that separated the northern and southern supercontinents.
4. The single supercontinent in Wegener's theory.
(A) P-1, Q-2, R-3, S-4
(B) P-4, Q-3, R-2, S-1
(C) P-4, Q-2, R-3, S-1
(D) P-2, Q-4, R-1, S-3

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126. A ventifact is a rock that has been shaped, pitted, and polished by:
(A) River water
(B) Glacial ice
(C) Chemical solution
(D) Wind-driven sand

127. Which of the following is NOT a characteristic feature of a Karst region?
(A) Drumlins
(B) Sinkholes

(C) Caves
(D) Disappearing streams

128. The movement of sediment parallel to the shoreline by wave action is known as:
(A) Backwash
(B) Longshore drift
(C) Swash
(D) Tidal current

129. The main significance of identifying different drainage patterns is that they provide clues about the:
(A) Climate of the region.
(B) Underlying rock structure and topography.
(C) Age of the river system.
(D) Flora and fauna of the area.

130. The zone within the Earth from about 105 to 140 degrees from an earthquake's epicenter, which does not receive direct P-waves, is known as the:
(A) P-wave shadow zone
(B) Low-velocity zone
(C) S-wave shadow zone
(D) High-velocity zone

131. The world distribution of volcanoes shows a strong concentration along:
(A) The interiors of continental shields.
(B) Major river valleys.
(C) The margins of tectonic plates.
(D) The equatorial belt.

132. Which of the following provides evidence for isostasy?
(A) The existence of mid-ocean ridges.
(B) The presence of similar fossils on different continents.
(C) The reversal of Earth's magnetic field.
(D) The measurement of gravity anomalies over mountains and plains.

133. According to Wegener, which forces were responsible for continental drift?
(A) Mantle convection and slab pull
(B) Isostatic adjustment and erosion
(C) Pole-fleeing force and tidal force
(D) Ridge push and gravitational sliding

134. Which of the following features is characteristic of a continental-continental convergent boundary?
(A) A mid-ocean ridge
(B) A major non-volcanic mountain range
(C) A volcanic island arc
(D) A rift valley

135. Consider the following statements about landforms:
1. A gorge is a narrow, steep-sided valley, often cut by a river in its youthful stage.
2. A cirque is a depositional feature found at the terminus of a glacier.
3. A barchan is a type of dune formed by wind.

Which of the above statements is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

136. The slow, gradual downslope movement of water-saturated soil and regolith in periglacial environments is called:
(A) Solifluction
(B) Soil creep
(C) Landslide
(D) Rockfall

137. Which type of river is characterized by multiple, interlacing channels with numerous bars and islands?
(A) Meandering river
(B) Straight river
(C) Braided river
(D) Antecedent river

138. Kames and eskers are both landforms composed of:
(A) Sorted sand and gravel deposited by meltwater.
(B) Unsorted till deposited directly by ice.
(C) Wind-blown silt (loess).
(D) Chemically precipitated limestone.

139. A 'mushroom rock' or 'pedestal rock' is a classic landform produced by:
(A) Glacial plucking
(B) Fluvial corrosion
(C) Marine hydraulic action
(D) Aeolian abrasion

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140. A tower karst landscape, characterized by steep, isolated limestone peaks, is famously found in:
(A) The central Sahara Desert
(B) Parts of Southern China and Vietnam
(C) The plains of Siberia
(D) The coastline of Norway

141. The formation of a sea arch is an intermediate stage in the erosion of a:
(A) Beach
(B) Tombolo
(C) Headland
(D) Bay

142. In morphometric analysis, 'hypsometric analysis' is used to study the:
(A) Pattern of stream networks.
(B) Shape and elongation of the basin.
(C) Texture of the topography.
(D) Distribution of area with respect to elevation in a drainage basin.

143. The Gutenberg Discontinuity separates the:
(A) Mantle and Core
(B) Crust and Mantle
(C) Outer Core and Inner Core
(D) Lithosphere and Asthenosphere

144. Which of the following is NOT a cause of subsidence in a geosyncline?
(A) Weight of accumulated sediments
(B) Orogenic uplift
(C) Thinning of the crust
(D) Phase change in the underlying mantle material

145. The following question consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Examine these two statements carefully and select the correct answer using the options given below:
Assertion (A) : The Himalayas are still geologically active and continue to rise.
Reason (R) : The Indian plate continues to push northwards into the Eurasian plate.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

146. A radial drainage pattern is most likely to develop on a:
(A) Volcanic cone
(B) Folded mountain belt
(C) Coastal plain
(D) Fault-block landscape

147. A hanging valley is formed when:
(A) A main river erodes its valley faster than its tributaries.
(B) A large landslide blocks a river valley.
(C) A main glacier erodes much deeper than tributary glaciers.
(D) Sea level rises and floods a river valley.

148. Which of these depositional features is NOT associated with glaciers?
(A) Moraine
(B) Drumlin
(C) Esker
(D) Natural Levee

149. The conditions for the development of Karst topography are best met in regions with:
(A) Thin sandstone bedrock, low rainfall, and a high water table.
(B) Impermeable granite bedrock and moderate rainfall.
(C) Thick limestone bedrock, high rainfall, and a deep water table.
(D) Unconsolidated sediments and arid climate.

150. What is a primary difference between a landslide and soil creep?
(A) Landslides involve rock, while soil creep involves soil.
(B) Landslides are rapid movements, while soil creep is very slow.
(C) Landslides only occur in wet conditions.
(D) Landslides are erosional, while soil creep is depositional.

151. Which Indian region is classified under Zone V?
(A) The Deccan Plateau
(B) The Indo-Gangetic Plain
(C) The Thar Desert
(D) The Himalayan region and Northeast India

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152. The recording of the Earth's magnetic field at the time of rock formation is known as:
(A) Thermoremanent magnetization

(B) Geomagnetic reversal
(C) Isostatic magnetism
(D) Magnetic declination

153. A central concept in plate tectonics is that the Earth's surface is composed of a series of rigid slabs called:
(A) Geosynclines
(B) Continental shelves
(C) Lithospheric plates
(D) Asthenospheric cells

154. In the Davisian cycle, a peneplain with isolated hills of resistant rock is the hallmark of which stage?
(A) Old Age
(B) Youth
(C) Early Maturity
(D) Late Maturity

155. Waterfalls and rapids are most characteristic of which stage of river development?
(A) Mature stage
(B) Old age stage
(C) Rejuvenated stage
(D) Youthful stage

156. An outwash plain is a depositional feature formed by:
(A) Wind in a desert environment.
(B) Meltwater streams flowing from the terminus of a glacier.
(C) A river flooding its banks.
(D) Waves depositing sand on a coastline.

157. Which erosional process of wind involves the grinding and scraping of a rock surface by particles carried in the wind?
(A) Deflation
(B) Attrition
(C) Abrasion
(D) Solution

158. Stalactites and stalagmites are depositional features found in:
(A) Volcanic craters
(B) River channels
(C) Glacial valleys
(D) Caves

159. The study of the shape, size, and geometry of landforms is known as:
(A) Geomorphology
(B) Geochronology
(C) Seismology
(D) Petrology

160. Match List I with List II regarding proponents and their theories:
List I: (Proponent)
P. W. M. Davis
Q. A. Wegener
R. H. Hess
S. G. B. Airy
List II: (Theory/Concept)
1. Isostasy (Root Hypothesis)
2. Sea Floor Spreading
3. Continental Drift
4. Cycle of Erosion
(A) P-1, Q-2, R-3, S-4
(B) P-4, Q-3, R-2, S-1
(C) P-4, Q-1, R-2, S-3
(D) P-3, Q-4, R-1, S-2

161. What is the primary cause of volcanic eruptions?
(A) The gravitational pull of the moon causing magma to rise.
(B) The release of pressure on superheated magma, allowing gases to expand.
(C) The accumulation of rainwater in volcanic vents.
(D) The chemical reaction between different types of rock in the mantle.

162. The theory of isostasy helps to explain all of the following EXCEPT:
(A) The formation of mid-oceanic ridges.
(B) The uplift of land after an ice sheet melts.
(C) The presence of deep roots" beneath high mountains.
(D) The subsidence of a delta region due to sediment deposition.

163. The Glossopteris flora is significant in geology as it provides strong fossil evidence for:
(A) The timing of the last ice age.
(B) The evolution of marine life.
(C) The existence of the supercontinent Gondwanaland.
(D) The process of Karst formation.

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164. What is the fundamental difference between a sea and an ocean basin?
(A) Seas contain saltwater, while ocean basins are freshwater.
(B) Seas lack tides, whereas ocean basins experience them.
(C) Seas are situated exclusively in the Northern Hemisphere.
(D) Seas are smaller and partially enclosed by land.

165. The movement of plates at a divergent boundary results in:
(A) Orogenesis
(B) Subduction and crustal destruction
(C) Rifting and the formation of new crust
(D) Strike-slip faulting

166. A trellis drainage pattern is indicative of:
(A) A landscape of uniform, homogeneous rock.
(B) A region of folded or tilted sedimentary rocks with varying resistance.
(C) A volcanic cone or dome.
(D) A large, flat basin.

167. A U-shaped valley is a classic landform created by:
(A) River erosion in a mature stage.
(B) Wind erosion in a desert.
(C) Tectonic rifting.
(D) Glacial erosion.

168. Parabolic dunes are distinct from barchans in that:
(A) Their horns point upwind, often anchored by vegetation.
(B) They are linear ridges oriented parallel to the wind.
(C) They are composed primarily of rock rather than sand.
(D) They are situated exclusively in coastal environments.

169. What is a polje in a Karst landscape?
(A) A small, circular depression.
(B) A column formed by the joining of a stalactite and stalagmite.
(C) A large, flat-floored, closed depression.
(D) A stream that disappears underground.

170. Consider the following statements about geomorphic agents:
1. Fluvial refers to processes related to river action.
2. Aeolian refers to processes related to wind action.
3. Glacial refers to processes related to ice action.

Which of the above statements is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

171. A bay mouth bar is a depositional feature that:
(A) Connects an island to the mainland.
(B) Lies parallel to the coast, separated by a lagoon.
(C) Is a rocky outcrop extending from a headland.
(D) Forms a sandy ridge across the entrance to a bay.

172. The Lehmann discontinuity is the boundary between the:
(A) Outer core and inner core.
(B) Mantle and outer core.
(C) Crust and mantle.
(D) Lithosphere and asthenosphere.

173. Hotspot volcanism, such as that which formed the Hawaiian Islands, is caused by:
(A) The subduction of an oceanic plate.
(B) Rifting at a divergent plate boundary.
(C) A stationary plume of hot material rising from deep within the mantle.
(D) The collision of two continental plates.

174. The concept of polar wandering is best explained by:
(A) The physical migration of the magnetic poles over the Earth's surface.
(B) The periodic reversal of the Earth's magnetic field.
(C) Changes in the Earth's axial tilt.
(D) The movement of continents relative to fixed magnetic poles.

175. The formation of the Andes mountains is a direct result of:
(A) The subduction of the Nazca plate beneath

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the South American plate.
(B) The collision of two continental plates.
(C) Rifting of the South American continent.
(D) A transform fault boundary.

176. Which of the following is an example of an antecedent drainage system?
(A) A river that flows down the slope of a newly formed volcano.
(B) A river that is able to maintain its course by cutting through a slowly uplifting mountain range.
(C) A river system that develops on a uniform, gently sloping plain.
(D) A river whose course is determined by a network of faults and joints.

177. A terminal moraine marks the:
(A) Side of a valley glacier.
(B) Farthest point of advance of a glacier.
(C) Middle of a glacier where two glaciers have joined.
(D) Material deposited at the base of a glacier.

178. Star dunes are indicative of:
(A) Variable wind directions.
(B) A single, constant wind direction.
(C) Two dominant wind directions at right angles.
(D) Wind blowing from a central point outwards.

179. A disappearing stream is a common feature in which type of topography?
(A) Glacial
(B) Aeolian
(C) Karst
(D) Volcanic

180. The following question consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Examine these two statements carefully and select the correct answer using the options given below:
Assertion (A) : In a Karst region, surface drainage is often poorly developed or absent.
Reason (R) : The soluble nature of limestone allows water to percolate downwards and flow through underground channels.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

181. A long, narrow offshore ridge of sand, parallel to the coast and separated from it by a lagoon, is a:
(A) Tombolo
(B) Spit
(C) Barrier island
(D) Sea stack

182. Which of the following is NOT a fundamental principle of geomorphology?
(A) A delicate balance exists between landforms and the processes that create them.
(B) Geomorphic processes operate independently of the geologic structure.
(C) Different geomorphic processes operate at different rates.
(D) The geomorphic history of a region can be complex.

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183. The focus or hypocenter of an earthquake is:
(A) The point on the surface directly above the origin.
(B) The point where the earthquake's intensity is greatest.
(C) The furthest point from the origin where shaking is felt.
(D) The point within the Earth where the fault rupture originates.

184. The lithosphere is best defined as:
(A) The rigid outer layer of the Earth, consisting of the crust and upper mantle.
(B) The liquid outer core of the Earth.
(C) The partially molten layer of the upper mantle.
(D) The entire solid Earth.

185. Geosynclines are often classified based on their:
(A) Age and rock type.
(B) Dominant geomorphic agent.
(C) Geographic location relative to continents and oceans.
(D) Climatic zone.

186. The concept of sea-floor spreading provides a mechanism for:
(A) Continental drift.
(B) The formation of mountains.

(C) Isostatic adjustment.
(D) The cycle of erosion.

187. The collision of the Indian Plate with the Eurasian Plate is an example of what type of convergent boundary?
(A) Oceanic-Oceanic
(B) Oceanic-Continental
(C) Transform-Continental
(D) Continental-Continental

188. In fluvial geomorphology, the process by which river-borne particles collide with each other and are broken down is called:
(A) Abrasion
(B) Attrition
(C) Hydraulic action
(D) Solution

189. A pyramidal peak formed by the headward erosion of several cirques around a single mountain is known as a:
(A) Arête
(B) Nunatak
(C) Horn
(D) Fjord

190. Consider the following geomorphic agents:
1. Wind
2. Water (River)
3. Ice (Glacier)
What is the order of their typical effectiveness in sorting sediments, from best sorted to least sorted?
(A) 1, 2, 3
(B) 3, 2, 1
(C) 2, 1, 3
(D) 1, 3, 2

191. The term 'regolith' refers to:
(A) A layer of loose, weathered rock and mineral fragments covering bedrock.
(B) The solid bedrock underlying a landscape.
(C) The organic topsoil layer.
(D) A type of metamorphic rock.

192. Which of the following is the best example of a depositional feature of marine origin?
(A) Wave-cut platform
(B) Beach
(C) Sea cave
(D) Sea cliff

193. The primary significance of morphometric analysis is its:
(A) Qualitative and descriptive nature.
(B) Quantitative and objective approach to describing landforms.
(C) Focus on historical geology.
(D) Exclusive application to large-scale continental features.

194. The S-wave shadow zone is larger than the P-wave shadow zone because:
(A) S-waves cannot travel through the liquid outer core.
(B) S-waves travel slower than P-waves.
(C) S-waves are absorbed by the mantle.
(D) S-waves are reflected at the crust-mantle boundary.

195. Viscous, silica-rich magma is most likely to produce:
(A) A shield volcano with gentle slopes.
(B) A flood basalt plateau.
(C) An explosive eruption and a stratovolcano.
(D) A mid-ocean ridge.

196. The uplift of a mountain range after significant erosion has occurred is an example of:
(A) Tectonic compression
(B) Volcanic activity
(C) Sea-floor spreading
(D) Isostatic response

197. Which of the following is NOT a type of plate boundary?
(A) Convergent
(B) Divergent
(C) Geosynclinal
(D) Transform

198. An interruption in the cycle of erosion, such as by tectonic uplift or a change in sea level, leads to a process called:
(A) Aggradation
(B) Rejuvenation
(C) Peneplanation
(D) Mass wasting

199. A river terrace is a:
(A) Depositional feature currently being formed

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by the river.
(B) Sharp bend in a river.
(C) Man-made structure to control flooding.
(D) Remnant of a former floodplain now at a higher elevation than the current river.

200. Match List I with List II regarding aeolian landforms:
List I: (Aeolian Landform)
P. Barchan
Q. Yardang
R. Loess
S. Ventifact
List II: (Description)
1. Wind-faceted pebble or stone
2. Blanket of fine, wind-deposited silt
3. Crescent-shaped dune with horns pointing downwind
4. Elongated, wind-eroded ridge
(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-4, R-2, S-1
(C) P-3, Q-2, R-4, S-1
(D) P-4, Q-3, R-1, S-2

201. The 'Ring of Fire' is associated with which ocean?
(A) Atlantic Ocean
(B) Indian Ocean
(C) Pacific Ocean
(D) Arctic Ocean

202. The concept of isostasy implies that for every mass excess at the surface (like a mountain), there is a:
(A) Mass deficiency below.
(B) Further mass excess below.
(C) Laterally displaced mass.
(D) Region of high-density rock below.

203. Alfred Wegener's professional background was primarily in:
(A) Geology and Paleontology
(B) Oceanography and Marine Biology
(C) Physics and Chemistry
(D) Meteorology and Climatology

204. Which of the following is a key feature of a subduction zone?
(A) Formation of new oceanic crust.
(B) A deep oceanic trench.
(C) A mid-oceanic ridge.
(D) Normal faulting and crustal thinning.

205. The 'principle of uniformitarianism' can be summarized as:
(A) The end justifies the means."
(B) Catastrophic events are the primary shapers of the Earth."
(C) The present is the key to the past."
(D) All landscapes evolve towards a peneplain."

206. Which of the following is a fluvial erosional landform?
(A) Delta
(B) Alluvial fan
(C) Point bar
(D) Gorge

207. Glacial till is best described as:
(A) Unsorted, unstratified debris deposited directly by glacial ice.
(B) Well-sorted sand and gravel deposited by meltwater.
(C) A mixture of finely ground rock flour and water.
(D) A layer of wind-blown silt.

208. The main chemical process involved in the formation of Karst topography is:
(A) Oxidation of iron
(B) Carbonation of calcium carbonate
(C) Hydrolysis of silicates
(D) Hydration of minerals

209. Consider the following case: A coastline is experiencing a gradual rise in sea level. Which of the following features is most likely to be formed as a result?
(A) Raised beaches and marine terraces.
(B) Rias and fjords (drowned valleys).
(C) Incised meanders and river rejuvenation.
(D) An increase in the height of sea cliffs.

210. Consider the following statements about plate tectonics:
1. Plates are in constant, slow motion.
2. Most major earthquakes occur along plate boundaries.
3. The continents themselves are not part of the plates, but ride on top of them.
Which of the above statements is/are correct?
(A) 1 and 2 only

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(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

211. In the context of valley development, 'aggradation' refers to the process of:
(A) Deepening the valley floor.
(B) Widening the valley sides.
(C) The river building up its bed with sediment.
(D) The capture of one stream by another.

212. What is a nunatak?
(A) A deposit of glacial till.
(B) A crack or fissure in a glacier.
(C) A deep, drowned glacial valley.
(D) An exposed rock peak or summit not covered with ice within a glacier or ice sheet.

213. What is the primary difference between a sand dune and loess?
(A) Dunes are erosional, loess is depositional.
(B) Dunes are formed by water, loess is formed by wind.
(C) Dunes are made of sand, loess is made of silt.
(D) Dunes are found in deserts, loess is found in glacial regions.

214. A 'doline' is another term for a:
(A) Cave
(B) Sinkhole
(C) Karst tower
(D) Underground river

215. The zig-zag movement of sand along a beach is a direct result of:
(A) Tidal currents.
(B) Rip currents.
(C) Tsunami waves.
(D) The action of swash and backwash.

216. The concept of a 'geomorphic threshold' refers to:
(A) The point at which a system is forced to change, often abruptly, due to a change in conditions.
(B) The final stage of landscape evolution.
(C) The lowest level to which a river can erode.
(D) The boundary between two different landform regions.

217. The East African Rift Valley is a modern example of:
(A) A continental-continental collision zone.
(B) An oceanic subduction zone.
(C) A developing divergent plate boundary.
(D) A transform fault system.

218. The term 'Miogeosyncline' refers to a geosyncline located:
(A) On the continental side, lacking intense volcanic activity.
(B) On the oceanic side of a volcanic arc.
(C) In the middle of a continental plate.
(D) Between two colliding continents.

219. The 'old age' stage of the fluvial cycle of erosion is characterized by:
(A) Steep gradients and V-shaped valleys.
(B) Perfect balance between erosion and deposition.
(C) Maximum relief and active downcutting.
(D) A wide floodplain, meanders, and oxbow lakes.

220. The following question consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Examine these two statements carefully and select the correct answer using the options given below:
Assertion (A) : Mid-oceanic ridges are sites of shallow-focus earthquakes.
Reason (R) : The lithosphere is thin and hot at mid-oceanic ridges, and crustal extension occurs through normal faulting.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

221. A point bar is a depositional feature found:
(A) On the outer bank of a meander.
(B) In the middle of a braided stream.
(C) On the inner bank of a meander.
(D) At the mouth of a river.

222. An erosional surface of low relief, formed in arid or semi-arid regions by the coalescence of pediments, is called a:
(A) Peneplain

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(B) Panplain
(C) Etchplain
(D) Pediplain

223. What type of glacier is confined to a valley?
(A) Valley glacier (or Alpine glacier)
(B) Ice sheet
(C) Ice cap
(D) Piedmont glacier

224. Which of the following is an example of a landslide?
(A) The slow, imperceptible downhill movement of topsoil.
(B) The sudden and rapid movement of a coherent mass of rock or debris down a slope.
(C) The accumulation of sand into a large hill by wind.
(D) The sinking of the ground surface due to groundwater withdrawal.

225. The measurement of relief, slope, and drainage network characteristics falls under the purview of:
(A) Seismology
(B) Morphometric analysis
(C) Paleoclimatology
(D) Geochronology

226. The asthenosphere is the layer of the Earth upon which the tectonic plates move. It is characterized as being:
(A) Ductile and capable of slow flow.
(B) Rigid and brittle.
(C) Liquid and metallic.
(D) Solid and highly pressurized.

227. A 'caldera' is a large volcanic feature formed by:
(A) The accumulation of lava flows from a fissure.
(B) The slow erosion of a volcanic cone.
(C) The collapse of a volcano into its own magma chamber after a massive eruption.
(D) The forceful intrusion of magma that domes the overlying rock.

228. The main objection to Wegener's continental drift theory from the scientific community of his time was:
(A) The lack of evidence for the fit of the continents.
(B) Fossil evidence was shown to be fraudulent.
(C) His theory contradicted the existence of geosynclines.
(D) The proposed mechanism was physically implausible.

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229. A landform created by a stream flowing across a coastal plain from a highland area is a/an:
(A) Delta
(B) Peneplain
(C) Alluvial Fan
(D) Oxbow lake

230. A drumlin is a glacial landform described as:
(A) A sinuous ridge of sorted sand and gravel.
(B) An asymmetrical till hill with its steep side facing the ice source.
(C) An amphitheater-shaped hollow at a glacial valley head.
(D) A sharp, knife-edged ridge between adjacent valleys.

231. The process of 'deflation' in an aeolian environment refers to:
(A) The grinding action of wind-borne particles.
(B) The deposition of sand into dunes.
(C) The chemical weathering of rocks by wind-carried moisture.
(D) The lifting and removal of loose material by wind.

232. 'Terra rossa' is a type of red clay soil often found in:
(A) Karst environments
(B) Glacial environments
(C) Desert environments
(D) Volcanic environments

233. The sequential erosion of a headland follows which order?
(A) Arch, Cave, Stack, Stump
(B) Stack, Arch, Cave, Stump
(C) Cave, Arch, Stack, Stump
(D) Cave, Stack, Arch, Stump

234. In geomorphology, a graded stream is a stream that has:
(A) Achieved a balance between its transporting capacity and the sediment load it has to carry.

(B) A very steep gradient and is actively downcutting.
(C) Ceased to flow due to a change in climate.
(D) A perfectly straight channel.

235. The concept that large-scale geological changes are the result of sudden, short-lived, violent events is known as:
(A) Uniformitarianism
(B) Gradualism
(C) Isostasy
(D) Catastrophism

236. The Mid-Atlantic Ridge is a prime example of a:
(A) Convergent plate boundary
(B) Divergent plate boundary
(C) Transform plate boundary
(D) Hotspot track

237. The 'Eugeosyncline' part of a geosynclinal couple is characterized by:
(A) Its location on the stable continent.
(B) A lack of volcanic material.
(C) Its location on the oceanic side with associated volcanism.
(D) Thin sedimentary deposits.

238. Which of these is NOT considered evidence for continental drift?
(A) Distribution of fossils like Mesosaurus
(B) Paleoclimatic indicators like coal beds in Antarctica
(C) The continuity of geological structures across oceans
(D) The presence of mid-ocean ridges

239. A cirque glacier is a type of:
(A) Alpine glacier found in a mountain hollow
(B) Ice sheet
(C) Ice cap
(D) Valley glacier

240. Match List I with List II regarding mass wasting terms:
List I: (Term)
P. Landslide
Q. Soil Creep
R. Rockfall
S. Mudflow
List II: (Definition)
1. Free-fall of rock from a cliff face
2. Very slow, continuous movement of soil
3. Rapid flow of saturated soil and debris
4. Rapid downslope movement of a mass
(A) P-4, Q-2, R-1, S-3
(B) P-2, Q-4, R-3, S-1
(C) P-4, Q-1, R-2, S-3
(D) P-3, Q-2, R-1, S-4

241. A volcanic mudflow or debris flow is known as a:
(A) Pyroclastic flow
(B) Lahar
(C) Lava flow
(D) Fumarole

242. The concept of isostatic equilibrium was first developed by observing:
(A) Deflections of the plumb line near large mountain masses.
(B) The depth of the oceans.
(C) The height of volcanoes.
(D) The patterns of earthquake waves.

243. The supercontinent that existed before Pangaea is often referred to as:
(A) Laurasia
(B) Gondwana
(C) Rodinia
(D) Columbia

244. The Andes Mountains are formed at which type of plate margin?
(A) Convergent (Continental-Continental)
(B) Divergent (Continental)
(C) Transform
(D) Convergent (Oceanic-Continental)

245. The ultimate base level for most rivers is:
(A) A large lake
(B) A resistant rock layer
(C) Sea level
(D) The local water table

246. What is a fiard?
(A) A deep, U-shaped glacial trough drowned by the sea.
(B) A low-lying, irregular, drowned coastline of glacial origin.
(C) A drowned river valley located on a steep coastline.
(D) A lagoon created by a protective barrier

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island.

247. The bouncing or skipping of sand grains along the ground surface by wind is called:
(A) Suspension
(B) Creep
(C) Deflation
(D) Saltation

248. A 'uvala' in Karst topography is:
(A) A feature formed by the coalescence of several sinkholes.
(B) A single, small sinkhole.
(C) The scientific term for a cave.
(D) A surface stream that flows into a sinkhole.

249. A 'raised beach' is evidence of:
(A) A recent rise in sea level.
(B) Intense storm activity.
(C) A former shoreline that is now above the current sea level.
(D) The formation of a spit.

250. Consider the following statements about fluvial landforms:
1. An alluvial fan typically forms in a mountain front setting.
2. A delta forms where a river empties into a standing body of water.
3. A point bar is an erosional feature on the outside of a meander.

Which of the above statements is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

251. The quantitative description of a basin's geometry and its stream channel system is called:
(A) Geochronology
(B) Pedology
(C) Palynology
(D) Morphometric analysis

252. The 'low velocity zone' in the upper mantle is another name for the:
(A) Lithosphere
(B) Asthenosphere
(C) Mesosphere
(D) Inner Core

253. The Japanese islands are an example of a/an:
(A) Continental volcanic arc
(B) Hotspot chain
(C) Island arc at an oceanic-oceanic convergent boundary
(D) Continental rift zone

254. The process of stream capture, where one stream diverts the flow of another, is also known as:
(A) Stream rejuvenation
(B) Stream braiding
(C) Stream aggradation
(D) Stream piracy

255. A kame is a glacial landform described as:
(A) An irregular mound of sand and gravel in a retreating glacier.
(B) A long, sinuous ridge consisting of sand and gravel.
(C) A large boulder transported and deposited by a glacier.
(D) A smooth, streamlined hill composed mainly of till.

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256. A deflation hollow or 'blowout' is an erosional feature created by:
(A) Water
(B) Wind
(C) Ice
(D) Gravity

257. Which country is most famously associated with extensive Karst topography?
(A) Japan
(B) The former Yugoslavia (Slovenia, Croatia)
(C) Egypt
(D) Russia

258. A headland is more resistant to erosion than the surrounding coast because it is made of:
(A) Harder, more resistant rock
(B) Softer rock
(C) Unconsolidated sand
(D) Glacial till

259. Walther Penck's geomorphic model primarily emphasized the:
(A) Significant role of local climate.
(B) Absolute necessity of a final peneplain.
(C) Relation between rates of uplift and erosion.
(D) Fixed sequence of youth, maturity, and old

age.

260. The following question consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Examine these two statements carefully and select the correct answer using the options given below:
Assertion (A) : Paleo-magnetism provides strong support for the theory of plate tectonics.
Reason (R) : The pattern of magnetic anomalies on either side of mid-oceanic ridges is symmetrical, indicating the creation and spreading of new crust.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

261. The process of slope replacement, where a steep slope is replaced by a gentler one from the bottom upwards, is a key idea in the geomorphic model of:
(A) W.M. Davis
(B) G.K. Gilbert
(C) Walther Penck
(D) L.C. King

262. Which of the following is NOT a form of mass wasting?
(A) Landslide
(B) Abrasion
(C) Soil creep
(D) Slump

263. An annular drainage pattern is typically associated with:
(A) A coastal plain
(B) A block-faulted region
(C) A flat-lying sedimentary plateau
(D) An eroded dome or basin structure

264. An erratic is a glacial feature consisting of:
(A) A large boulder transported by ice and deposited in an area of different rock type.
(B) A deep scratch or groove on bedrock made by a glacier.
(C) A hollow at the head of a glacial valley.
(D) A ridge of till deposited at the edge of a glacier.

265. What causes the subsidence of a landmass in a geosyncline?
(A) Removal of material by erosion.
(B) Collision of two tectonic plates.
(C) The deposition of a large volume of sediments.
(D) A global fall in sea level.

266. A 'sea cave' is formed primarily by which erosional process?
(A) Hydraulic action
(B) Abrasion
(C) Solution
(D) Attrition

267. The hypsometric curve in morphometric analysis represents:
(A) The profile of a river from source to mouth.
(B) The relationship between stream order and number.
(C) Changes in slope along a specific valley side.
(D) Basin area distribution relative to elevation.

268. Which of the following features is not typically associated with a divergent plate boundary?
(A) Mid-ocean ridge
(B) Deep-focus earthquakes
(C) Rift valley
(D) Shallow earthquakes

269. The 'continental shelf', 'continental slope', and 'continental rise' are features of the:
(A) Deep ocean floor
(B) Mid-oceanic ridge system
(C) Continental margin
(D) Abyssal plain

270. Consider the following geological time units:
1. Epoch
2. Eon
3. Period
4. Era

What is the correct order from largest to smallest?
(A) 2, 4, 3, 1
(B) 1, 3, 4, 2
(C) 4, 2, 1, 3
(D) 2, 3, 4, 1

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271. When the horns of a barchan dune become elongated and the central part is removed, it may evolve into a:
(A) Seif or longitudinal dune
(B) Star dune
(C) Parabolic dune
(D) Reversing dune

272. A 'superimposed' drainage pattern is one that:
(A) Develops on a newly emerged surface, like a volcanic cone.
(B) Maintained its course while downcutting through underlying structures.
(C) Is controlled by the underlying geological structure from its inception.
(D) Flows towards a central basin.

273. The 'Pacific-type' continental margin is also known as an 'active margin' because it is characterized by:
(A) A wide continental shelf and lack of tectonic activity.
(B) Tectonic activity, including earthquakes and volcanism, due to a nearby plate boundary.
(C) Heavy sedimentation and delta formation.
(D) Isostatic stability and a gentle slope.

274. In Pratt's model of isostasy, higher mountains are composed of:
(A) Less dense rock
(B) Denser rock
(C) Rock with the same density as lowlands
(D) Rock with deeper roots

275. The final, nearly flat plain produced by the Davisian cycle of erosion is a:
(A) Pediplain
(B) Structural plain
(C) Peneplain
(D) Panplain

276. A Piedmont glacier is formed when:
(A) A glacier is confined to a single mountain valley.
(B) A large ice sheet covers an entire continent.
(C) A small glacier occupies a cirque hollow.
(D) Valley glaciers coalesce on the plains below.

277. The term 'inselberg' is German for:
(A) Ice mountain
(B) Fold mountain
(C) Island mountain
(D) Sand mountain

278. Which of the following is an example of a hotspot track?
(A) The Andes Mountains
(B) The Hawaiian-Emperor seamount chain
(C) The Mid-Atlantic Ridge
(D) The San Andreas Fault

279. The study of the internal structure of the Earth relies heavily on the analysis of:
(A) Rock samples from deep drilling
(B) Volcanic ejecta
(C) Satellite imagery
(D) Seismic wave behavior

280. Match List I with List II regarding landforms and their dominant processes:
List I: (Landform)
P. Alluvial Fan
Q. Esker
R. Yardang
S. Sea Stack
List II: (Dominant Process)
1. Aeolian Abrasion
2. Fluvio-glacial Deposition
3. Fluvial Deposition
4. Marine Erosion
(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-4, R-2, S-1
(C) P-3, Q-2, R-1, S-4
(D) P-4, Q-3, R-1, S-2

281. The erosional work of a river is accomplished by all of the following processes EXCEPT:
(A) Hydraulic action
(B) Abrasion
(C) Deflation
(D) Attrition

282. The 'Atlantic-type' continental margin is 'passive' because it is:
(A) Not located at a plate boundary and is relatively stable.
(B) Located at a plate boundary.
(C) Constantly experiencing volcanic eruptions.
(D) Being subducted.

283. Which of the following features is NOT depositional?

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(A) Alluvial fan
(B) Moraine
(C) Delta
(D) Gorge

284. A large crack that develops in the upper, brittle part of a glacier is called a:
(A) Moraine
(B) Crevasse
(C) Fjord
(D) Horn

285. A cone of depression is a feature associated with:
(A) Volcanic craters
(B) The impact of a meteorite
(C) Pumping of groundwater from a well
(D) A Karst sinkhole

286. Which one of the following is NOT an erosional feature of coastal geomorphology?
(A) Sea cliff
(B) Wave-cut platform
(C) Sea arch
(D) Tombolo

287. In morphometric analysis, the 'basin circularity ratio' is a measure of:
(A) The degree to which the basin shape approaches a circle.
(B) The length of the basin.
(C) The slope of the basin.
(D) The density of streams in the basin.

288. The most destructive seismic waves are typically the:
(A) P-waves
(B) Surface waves (Love and Rayleigh)
(C) S-waves
(D) Body waves

289. The 'level of compensation' is a concept central to which theory?
(A) Plate Tectonics
(B) Isostasy
(C) Cycle of Erosion
(D) Continental Drift

290. Consider the following statements regarding the Earth's interior:
1. The crust is the thinnest layer.
2. The mantle is the thickest layer by volume.
3. The core is composed primarily of silicate minerals.

Which of the above statements is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

291. The primary cause of landslides is:
(A) Wind erosion
(B) Glacial plucking
(C) Gravity acting on a steep, unstable slope
(D) River deposition

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292. A centripetal drainage pattern would be expected in:
(A) An area of parallel folded ridges.
(B) An isolated volcanic peak.
(C) A coastal plain with uniform sediments.
(D) A basin or structural depression.

293. The smooth, gentle upstream slope and the steep, jagged downstream slope of a roche moutonnée indicate that the glacier flowed:
(A) From the steep side to the gentle side.
(B) Parallel to the ridge.
(C) From the gentle side to the steep side.
(D) The feature provides no information on flow direction.

294. A 'desert pavement' is formed by which aeolian process?
(A) Abrasion
(B) Deflation
(C) Deposition
(D) Saltation

295. Which of the following is NOT a type of plate tectonic boundary?
(A) Constructive (Divergent)
(B) Destructive (Convergent)
(C) Conservative (Transform)
(D) Regressive (Isostatic)

296. A 'ria' is a coastal inlet formed by:
(A) The drowning of a river valley by a rise in sea level.
(B) The drowning of a glacial valley by a rise in sea level.
(C) The collapse of a volcanic caldera.
(D) Faulting of the coastline.

297. The concept of 'graded time' in geomorphology refers to:
(A) The absolute age of a landform in years.
(B) A period of rapid, catastrophic change.
(C) A time span during which a steady state or equilibrium is achieved in a landscape.
(D) The entire duration of a cycle of erosion.

298. The Mercalli scale is used to classify earthquakes based on:
(A) The observed effects and damage at a particular place.
(B) The amount of energy released at the focus.
(C) The amplitude of the seismic waves recorded.
(D) The size of the fault rupture.

299. In the context of Wegener's theory, Laurasia and Gondwanaland were separated by the:
(A) Pacific Ocean
(B) Atlantic Ocean
(C) Indian Ocean
(D) Tethys Sea

300. The erosional process by which a glacier lifts and removes blocks of rock from its bed is known as:
(A) Abrasion
(B) Plucking
(C) Attrition
(D) Deflation

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ANSWERS

1. (B) P-waves
Primary waves represent a category of body waves characterized by longitudinal motion. These seismic waves propagate by compressing and stretching materials through which they travel, similar to sound waves. As the fastest seismic waves, they arrive first at recording stations and can effectively move through both solid and liquid layers of the Earth's interior.

2. (A) Determining the time sequence of events in Earth's history
Geochronology involves the scientific determination of the age of rocks, fossils, and sediments through various dating methods. This discipline establishes a chronological framework for geologic events, allowing researchers to reconstruct the evolutionary timeline of the planet. It utilizes both absolute and relative dating techniques to quantify the timing of historical transformations throughout Earth's long existence.

3. (C) Both Statement I and Statement II
Scientific observation of seismic wave behavior reveals the physical state of the Earth's interior layers. The outer core is identified as liquid because shear waves cannot pass through it. Meanwhile, the inner core is recognized as solid; despite its extreme heat, the immense gravitational pressure forces the metallic iron-nickel mixture to maintain a crystalline structure.

4. (A) Both A and R are true and R is the correct explanation of A.
Seismic shear waves, also known as secondary waves, require a rigid medium to propagate through the ground. Because the outer core consists of liquid iron and nickel, it lacks the necessary rigidity to transmit these transverse waves. Consequently, a significant shadow zone is created where these specific waves cannot be detected after passing through the core.

5. (C) All earthquakes exclusively occur at plate boundaries.
While a majority of seismic activity is concentrated at tectonic plate margins, earthquakes can also occur within the interior of plates. These intraplate events are often triggered by the reactivation of ancient fault systems or local stresses. Additionally, human activities and volcanic eruptions serve as significant non-tectonic sources of ground shaking in various global regions.

6. (B) Isoseismic line
An isoseismic line is a mapping tool used to represent the geographical distribution of earthquake intensity. It connects various points where the observed damage and ground shaking are equivalent. These lines generally form irregular closed curves around the epicenter, reflecting how local geological structures and soil conditions influence the attenuation of seismic energy across the surface.

7. (A) P-4, Q-3, R-1, S-2
The internal layering of the planet is distinguished by chemical composition and physical states. The uppermost crust consists primarily of granitic and basaltic silicate rocks. Below this, the mantle contains denser silicates. The outer core is characterized by liquid iron and nickel, while the inner core remains solid due to the intense gravitational pressure at the center.

8. (A) Sea floor spreading and Plate Tectonics
Paleomagnetism involves the study of the magnetic field preserved in ancient rocks containing iron-bearing minerals. The symmetrical patterns of magnetic reversals found on either side of mid-oceanic ridges provide conclusive evidence that new crust is continuously forming and moving away from the ridge. This phenomenon fundamentally supports the theories of sea floor spreading and plate tectonics.

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9. (C) A broad, gently sloping volcano built from fluid basaltic lava flows.
Shield volcanoes are characterized by their expansive, low-profile shapes that resemble a warrior's shield lying on the ground. They form through the repeated eruption of highly fluid, basaltic lava that travels great distances before cooling. This low-viscosity flow prevents the buildup of steep slopes, resulting in a mountain with a very wide base area.

10. (A) Equilibrium between the lithosphere and asthenosphere
Isostasy describes the gravitational balance between the Earth's rigid lithosphere and the underlying semi-fluid asthenosphere. It explains how crustal blocks of varying thickness and density float at different levels. When weight is added or removed through processes like glaciation or erosion, the crust adjusts vertically to maintain a state of mechanical equilibrium within the mantle.

11. (C) 1 and 3 only
Volcanic activity is primarily driven by tectonic plate interactions, especially at subduction zones and divergent boundaries. The Pacific Ring of Fire is the most prominent example of such activity, hosting a majority of the world's active volcanoes. However, eruptions are not always explosive; many involve the quiet, effusive flow of lava, depending on magma composition and pressure.

12. (B) The Central Siberian Shield
Major seismic belts are typically located along active tectonic plate boundaries where significant crustal deformation occurs. The Circum-Pacific, Alpine-Himalayan, and Mid-Atlantic regions are well-known for frequent earthquakes. In contrast, ancient shield areas like the Central Siberian Shield are geologically stable cratons that experience very little tectonic activity and are not considered major earthquake belts.

13. (C) Airy and Pratt
The scientific development of isostasy was largely shaped by two distinct models proposed in the nineteenth century. George Airy suggested that crustal blocks have uniform density but varying thickness, forming deep roots beneath mountains. Conversely, John Pratt hypothesized that blocks have varying densities but sink to a uniform depth, achieving equilibrium through differences in rock compensation.

14. (D) Roots of lighter material extending deep into the denser substratum.
The Airy model of isostasy compares the Earth's crust to blocks of wood floating in water. It assumes that the crust has a constant density across all landforms. Therefore, higher mountains must be supported by deep roots of buoyant material that displace the denser mantle below, much like the submerged portion of a large iceberg.

15. (A) Both A and R are true and R is the correct explanation of A.
The Himalayan mountain range is highly prone to earthquakes because it marks a major convergent boundary. The ongoing northward movement of the Indian plate causes it to collide with the Eurasian plate, resulting in the accumulation of immense tectonic stress. The sudden release of this stored energy along faults in the collision zone generates frequent seismic events.

16. (B) A shallow marine depression that subsides as it accumulates sediment.
A geosyncline is defined as a large-scale, elongated depression in the Earth's crust that gradually sinks over long periods. As it subsides, it collects vast thicknesses of sedimentary and sometimes volcanic material. This geological feature is historically significant because the accumulated sediments within these troughs eventually undergo intense compression and folding to form major mountain ranges.

17. (B) The pattern of magnetic anomalies recorded in the rocks of the ocean floor.
Magnetic anomalies provide the most compelling evidence for the theory of sea-floor spreading. As magma rises and solidifies at mid-oceanic ridges, it records the prevailing magnetic orientation. The discovery of symmetrical, alternating bands of normal and reversed polarity on both sides of the ridge confirms that the oceanic crust is continuously being created and pushed outward.

18. (A) 4, 1, 2, 3
The conceptual evolution of geological theories began with mid-nineteenth-century ideas on isostasy. This was followed by Alfred Wegener's

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introduction of continental drift in nineteen twelve. Later, Harry Hess proposed sea floor spreading in the early nineteen sixties. These developments culminated in the late nineteen sixties with the comprehensive theory of plate tectonics, which unified various geological and geophysical observations.

19. (C) Pangaea
Alfred Wegener proposed that all the Earth's continents were once joined together in a single, massive supercontinent approximately two hundred million years ago. He named this landmass Pangaea, which translates to all lands." Over time, the forces of continental drift caused this supercontinent to break apart, eventually forming the distinct continental configurations that we observe on Earth today.

20. (D) Mid-oceanic ridges
Divergent plate boundaries occur where tectonic plates move away from each other. As the crust pulls apart, magma rises from the mantle to fill the gap, cooling to form new oceanic lithosphere. This process creates mid-oceanic ridges, which are essentially underwater mountain ranges characterized by volcanic activity and shallow earthquakes, marking the site of continuous sea-floor spreading.

21. (C) Orogenic (mountain-building) forces.
The evolution of a geosyncline reaches its climax during the orogenic phase, where the accumulated layers of sediment are subjected to intense lateral compression. These forces cause the sediments to fold, fault, and rise upward. This dramatic structural transformation converts the former marine depression into a complex mountain range, marking the final transition from a subsiding basin to high terrain.

22. (B) P-4, Q-3, R-1, S-2
Specific geological features are directly linked to the type of tectonic plate interaction occurring at their boundaries. Subduction of oceanic crust beneath a continent creates mountain chains like the Andes. Continental collisions form high ranges like the Himalayas. Divergence in the ocean creates ridges like the Mid-Atlantic Ridge, while transform boundaries produce horizontal faulting like the San Andreas Fault.

23. (D) Paleomagnetic stripes on the ocean floor
Alfred Wegener supported his continental drift theory using multiple lines of evidence, including the matching shapes of continents and similar fossils across oceans. He also cited ancient climatic indicators, such as glacial deposits in currently tropical areas. However, the discovery of paleomagnetic stripes on the sea floor occurred decades after his death and served to confirm his initial hypothesis.

24. (A) The continents have moved relative to the fixed magnetic poles.
Polar wandering refers to the apparent movement of the Earth's magnetic poles over geological time as recorded in ancient rocks. Scientific analysis revealed that the magnetic paths from different continents did not match. This discrepancy is best explained by the movement of the continents themselves relative to the poles, rather than the poles moving independently across the planet's surface.

25. (C) Convection currents within the Earth's mantle.
The movement of tectonic plates is primarily powered by the circulation of heat within the Earth's mantle. Radioactive decay in the core generates intense heat, causing the semi-plastic asthenosphere to rise, cool, and sink in a continuous cycle. These massive convection currents act as a conveyor belt, dragging the overlying lithospheric plates and driving the process of plate tectonics.

26. (A) The scientific study of landforms and the processes that create and shape them.
Geomorphology is a branch of geography and geology that focuses on the physical features of the Earth's surface. It investigates how various natural agents, such as water, wind, ice, and tectonic forces, interact to sculpt the landscape over time. Researchers in this field analyze the origin, evolution, and distribution of diverse landforms to understand the planet's history.

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27. (D) Neither Statement I nor Statement II
In plate tectonics, the creation and destruction of oceanic crust occur at specific boundary types. New crust is generated at divergent boundaries, where plates pull apart and magma rises. Conversely, old crust is consumed and destroyed

at convergent boundaries, specifically within subduction zones. Therefore, both statements provided in the question incorrectly identify the processes associated with these tectonic margins.

28. (A) 1 and 2 only
The Himalayas represent a classic example of fold mountains created by the intense horizontal compression of sedimentary layers. This formation resulted from the ongoing collision between the Indian and Eurasian plates. While the mountains are already the highest on Earth, the tectonic plates are still moving, meaning the range continues to rise and remains geologically active today.

29. (C) William Morris Davis
William Morris Davis developed the first systematic theory of landscape evolution, known as the geographical cycle or the cycle of erosion. He proposed that landforms undergo a predictable sequence of changes driven by fluvial processes. According to his model, the landscape transitions through stages of youth, maturity, and old age, ultimately resulting in a nearly flat plain called a peneplain.

30. (A) Both A and R are true and R is the correct explanation of A.
During an ice age, the immense weight of continental glaciers causes the underlying crust to sink into the mantle. When the climate warms and the ice melts, this heavy load is removed. The lithosphere then begins to slowly rise back to its original position in a process called isostatic rebound, which continues for thousands of years after deglaciation.

31. (A) Soil creep
Mass wasting is categorized by the speed of movement and the nature of the displaced material. Soil creep is the slowest form, occurring at a rate of only a few millimeters per year. It is a continuous, gravity-driven process that gradually moves soil and weathered rock downhill. Unlike rapid events like landslides or rockfalls, its effects are only visible over long periods.

32. (B) To understand the underlying geological structure and rock type.
Drainage patterns are the geometric arrangements formed by streams and rivers in a particular region. These patterns are highly sensitive to the nature of the terrain. By analyzing the layout of a drainage network, geologists can infer the type of underlying rocks, the presence of faults or folds, and the overall tectonic history of the landscape without direct excavation.

33. (B) The river has experienced a period of rapid uplift and downcutting.
An incised meander forms when a river that was already meandering on a floodplain is suddenly rejuvenated. This rejuvenation is typically caused by a tectonic uplift of the land or a significant drop in sea level. The increased energy allows the river to cut vertically into its bed, preserving the winding pattern deep within a narrow, steep-walled canyon.

34. (A) Alluvial fan
Streams create various landforms through the processes of erosion and deposition. While features like gorges and waterfalls result from the removal of rock, alluvial fans are built through the accumulation of sediment. They typically form where a fast-moving stream leaves a narrow mountain canyon and enters a flat plain, causing it to slow down and deposit its heavy load.

35. (C) Massive igneous rocks or uniform, flat-lying sedimentary rocks.
A dendritic drainage pattern resembles the branching structure of a tree. This layout develops in regions where the underlying rock layers provide uniform resistance to erosion in all directions. Because the geology is homogeneous, such as in massive igneous structures or horizontal sedimentary beds, the direction of stream flow is determined primarily by the gentle slope of the land surface.

36. (D) Sea Ice
Glaciers are masses of ice formed on land through the accumulation and compaction of snow over long periods. Common types include ice sheets, piedmont glaciers, and cirque glaciers, all of which move under their own weight. Sea ice, however, forms from the freezing of saltwater on the ocean surface and is not considered a glacier because it does not originate on land.

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37. (C) An arête
An arête is a narrow, jagged ridge of rock that remains after two adjacent glaciers have eroded parallel U-shaped valleys or neighboring cirques. The process of glacial plucking and abrasion on both sides thins the dividing wall until it becomes a sharp, knife-like feature. This landform is a classic indicator of intense alpine glaciation in high mountain regions.

38. (B) Drumlin
Drumlins are streamlined, asymmetrical hills composed of glacial till. These depositional features are shaped by the movement of an overriding ice sheet, with the steeper side facing the direction from which the ice originated. They typically occur in clusters known as drumlin fields, providing clear evidence of the direction and extent of past continental glaciations on the landscape.

39. (D) Deflation
Deflation is a specific process of wind erosion common in arid environments. It involves the lifting and removal of loose, fine-grained particles, such as silt and sand, from the ground surface. This process can lower the elevation of the land, sometimes creating large depressions called deflation hollows, and often leaves behind a surface of coarse pebbles known as desert pavement.

40. (A) Barchans
Barchans are crescent-shaped sand dunes that form in areas with a constant wind direction and a limited supply of sand. The horns" or tips of the crescent point downwind, in the direction the wind is blowing. These dunes are mobile and migrate across the desert floor as sand is blown up the windward slope and deposited on the steeper slip face.

41. (C) Presence of soluble limestone at or near the surface
Karst topography is a unique landscape formed primarily by the chemical dissolution of rocks. The most critical requirement for its development is a thick layer of soluble rock, most commonly limestone, located near the surface. When rainwater absorbs carbon dioxide, it becomes slightly acidic, allowing it to dissolve the calcium carbonate in the rock and create various distinctive underground and surface features.

42. (A) Karst
Landscapes characterized by sinkholes, caves, and intricate mineral formations like stalactites and stalagmites are known as Karst regions. These features are produced by the action of slightly acidic groundwater dissolving soluble bedrock over thousands of years. The process creates a complex drainage system where surface water often disappears into underground channels, leaving a rugged and unique terrain above.

43. (D) Marine erosion
A sea cliff is a steep, vertical rock face formed along a coastline. Its development is driven by the continuous mechanical action of waves crashing against the base of the shore. This process, known as hydraulic action and abrasion, undercuts the rock at the waterline, eventually causing the overlying material to collapse and retreat, leaving a sharp, high cliff behind.

44. (B) Tombolo
A tombolo is a coastal depositional landform consisting of a ridge of sand or gravel. It forms when waves and longshore currents deposit sediment in the sheltered water between an island and the mainland. Over time, this accumulation builds up until a permanent land bridge is created, effectively connecting the offshore island to the coast or to another nearby island.

45. (A) P-3, Q-4, R-1, S-2
Various natural agents sculpt the Earth's surface through erosion and deposition. Rivers create features like oxbow lakes during their mature stages. Glaciers deposit unsorted debris called moraines. Wind is responsible for the formation of barchan sand dunes in arid regions. Groundwater dissolution and subsequent mineral precipitation in limestone caves result in the growth of stalactites from the ceiling.

46. (D) The quantitative measurement and mathematical analysis of landform shapes.
Morphometric analysis involves the use of mathematical techniques to describe and analyze the physical characteristics of the landscape. It focuses on measuring parameters such as slope, elevation, drainage density, and basin shape. This

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quantitative approach allows geomorphologists to objectively compare different regions, understand tectonic influences, and model the hydrological behavior of various drainage basins with high precision.

47. (A) A large, rotating cloud of gas and dust.
The nebular hypothesis is a widely accepted theory explaining the origin of the solar system. It suggests that about four point six billion years ago, a massive interstellar cloud of gas and dust, called a nebula, began to collapse under its own gravity. As it rotated faster, it flattened into a disk, with the Sun forming at the center.

48. (A) Only Statement I
Seismic waves are classified based on their mode of propagation. P-waves are longitudinal, meaning particles move in the same direction as the wave. S-waves are transverse, with particle motion perpendicular to the wave's path. While P-waves are the fastest and arrive first, S-waves are slower and can only travel through solid materials, making the second statement in the question incorrect.

49. (B) Coriolis force
Earthquakes are primarily caused by the sudden release of energy due to geological processes. Common causes include tectonic plate movements along faults, volcanic activity, and isostatic adjustments of the crust. However, the Coriolis force is a result of the Earth's rotation that affects the movement of fluids like air and water; it has no direct role in triggering seismic events.

50. (A) 3 only
Both the Airy and Pratt models were developed to explain how the Earth's crust maintains gravitational equilibrium. Airy's model assumes uniform density with varying thickness, while Pratt's model assumes varying densities with a uniform depth of compensation. Since the first two statements in the question incorrectly swap these fundamental characteristics of the models, only the third statement remains factually correct.

51. (C) The weight of accumulating sediments.
In the traditional theory of geosynclines, the process of subsidence is largely attributed to the continuous deposition of sediment. As vast quantities of material are washed into a shallow marine basin, their combined weight exerts downward pressure on the crust. This causes the basin floor to sink gradually, allowing even more sediment to accumulate over millions of years.

52. (D) Tidal forces from the Moon
F.B. Taylor proposed an early version of continental drift, suggesting that the continents moved toward the equator. He hypothesized that during the Cretaceous period, the Earth captured the Moon, and the resulting massive tidal forces were strong enough to pull the continental masses across the surface. This mechanism was later proven to be physically impossible for moving large landmasses.

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53. (C) Oceanic-Oceanic convergent
Volcanic island arcs are chains of volcanic islands that form at convergent boundaries where two oceanic plates collide. As one plate is subducted beneath the other, it melts at depth, creating magma that rises through the overlying plate to the surface. This process results in a curved line of volcanoes, such as the Aleutian Islands or the Japanese archipelago.

54. (B) Uniformitarianism
Uniformitarianism is a fundamental principle of modern geology first proposed by James Hutton and popularized by Charles Lyell. It suggests that the geological processes observed today, such as erosion, deposition, and plate tectonics, have operated in the same manner throughout Earth's history. This concept allows scientists to interpret ancient rock formations by studying contemporary physical and chemical processes.

55. (A) Both A and R are true and R is the correct explanation of A.
A trellis drainage pattern forms in regions where rock layers of varying resistance have been folded or tilted. The main rivers occupy the valleys of weaker rocks, while their tributaries join at right angles after flowing down the slopes of harder, more resistant ridges. This creates a rectangular geometric network that reflects the underlying structural control of the folded terrain.

56. (A) Soil creep
Soil creep is the slowest and most widespread form of mass wasting. It involves the gradual, gravity-driven movement of soil and loose rock down a slope. While the motion is too slow to observe directly, it is often evidenced by the slow deformation of the surface, causing tree trunks to curve and fences or utility poles to tilt downhill.

57. (C) A V-shaped cross-profile and rapid downcutting.
In the youthful stage of a river cycle, the stream possesses high energy due to a steep gradient. Its primary work is vertical erosion, which results in the carving of deep, narrow, V-shaped valleys. During this stage, features like waterfalls, rapids, and gorges are common, and the river occupies nearly the entire floor of its narrow valley with minimal floodplain development.

58. (A) A deep, U-shaped glacial trough that has been drowned by the sea.
A fjord is a long, narrow marine inlet with steep sides or cliffs, created by glacial erosion. It forms when a glacier carves a deep U-shaped valley that extends below current sea level. After the glacier retreats and the climate warms, rising sea levels or the removal of ice allows the ocean to flood the valley, creating a deep waterway.

59. (D) Aeolian
Loess is a geomorphic feature composed of fine-grained, wind-blown silt and clay. It is an aeolian depositional landform that often originates from desert regions or areas of glacial outwash. Because these particles are easily transported by wind over long distances, they can accumulate in thick, unstratified blankets, forming fertile plains that are highly valuable for agriculture in various global regions.

60. (B) Subsurface dissolution in Karst regions
Caves, dolines, and poljes are classic landforms produced by the chemical weathering of soluble rocks, particularly limestone. This process involves the dissolution of calcium carbonate by slightly acidic groundwater. Over geological time, this subsurface erosion creates extensive underground networks and large surface depressions, resulting in a landscape where traditional surface drainage is often replaced by complex underground river systems.

61. (C) Spit
Coastal landforms are created by both erosional and depositional processes. While sea arches, stacks, and wave-cut platforms result from the destructive power of waves, a spit is formed through deposition. It is an elongated ridge of sand or gravel that extends from the shore into the mouth of an adjacent bay, built up by the action of longshore drift currents.

62. (D) Morphometric analysis
Morphometric analysis is the quantitative study of the surface features of a landscape. Parameters such as the relief ratio, which measures elevation differences, and drainage density, which quantifies the total length of streams, are used to describe the efficiency of a drainage basin. This mathematical approach helps scientists understand the relationship between the physical form of the land and the processes.

63. (A) Fissure eruption
Fissure eruptions occur when magma reaches the Earth's surface through long, linear cracks or fractures in the crust rather than a single central vent. These eruptions often involve highly fluid basaltic lava that spreads over vast areas. Over time, successive layers of lava can build up to form extensive flood basalt plateaus, such as the Deccan Traps in India.

64. (B) Neither P-waves nor S-waves are received directly.
The seismic shadow zone is a specific region on the Earth's surface where direct P-waves and S-waves from an earthquake cannot be detected. This occurs because the Earth's core refracts P-waves and completely blocks S-waves. By analyzing the size and location of this zone, seismologists have been able to determine the size and physical state of the planet's core.

65. (B) 2, 3, 1
The Davisian cycle of erosion describes the sequential evolution of a landscape following its rapid tectonic uplift. The process begins with the Youth" stage, characterized by steep gradients and deep valleys. This is followed by Maturity," where relief is maximized and floodplains begin to form. Finally, the Old Age" stage is reached, resulting in a flat, low-lying peneplain.

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66. (A) The record of the Earth's magnetic field preserved in rocks.
Paleomagnetism is the study of the Earth's magnetic history as recorded in iron-bearing minerals within rocks. When these minerals cool from magma or settle in sediments, they align themselves with the existing magnetic field. This permanent record allows scientists to track the past positions of tectonic plates and provides critical evidence for the theory of geomagnetic field reversals.

67. (C) Compressional stress leading to folding and faulting.
In the context of geosynclines, orogenic forces refer to the intense lateral compressional stresses that act upon the accumulated layers of sediment. These tectonic forces occur during the mountain-building phase, causing the sedimentary strata to buckle, fold, and fracture. This process results in the vertical uplift of the former marine basin, transforming it into a complex system of fold mountains.

68. (D) Proposed mechanism or driving force.
While both Taylor and Wegener proposed that continents move across the Earth's surface, they suggested very different reasons for this motion. Taylor attributed the movement to massive tidal forces generated by the Moon. Wegener, while also citing tidal forces, emphasized the pole-fleeing force. Both mechanisms were eventually found insufficient, leading to the later discovery of mantle convection as the true driver.

69. (C) Subduction zones at convergent boundaries.
Deep-sea trenches are the deepest parts of the ocean floor and are found at convergent plate boundaries. They form where one tectonic plate, usually oceanic, is forced beneath another plate and sinks into the mantle. This process of subduction creates a long, narrow depression on the sea floor, often accompanied by intense volcanic activity and frequent, high-magnitude earthquakes in the region.

70. (C) P-3, Q-4, R-1, S-2
Drainage patterns reflect the relationship between a river system and the underlying geology. Dendritic patterns resemble trees on uniform rock, while trellis patterns develop in folded terrains. Radial patterns occur when streams flow outward from a central peak, like a volcano. Conversely, centripetal patterns form when streams flow inward toward a central low point, such as a basin or depression.

71. (D) Glacial abrasion on the upstream side and plucking on the downstream side.
A roche moutonnée is a classic erosional landform created by the movement of a glacier over resistant bedrock. The side facing the ice flow is smoothed and polished through abrasion, resulting in a gentle slope. In contrast, the downstream side is steep and jagged because the glacier pulls away or plucks" large blocks of rock, revealing the direction of ice movement.

72. (A) Ridges of rock, oriented parallel to the prevailing wind, separated by grooves.
Yardangs are elongated, streamlined landforms created by wind erosion in arid regions. They consist of ridges of resistant rock or semi-consolidated material that have been sculpted into their characteristic shapes by the abrasive action of wind-blown sand. These features are always oriented parallel to the prevailing wind direction and are typically separated by deep, wind-scoured grooves or furrows.

73. (C) Glacial
A hanging valley is a characteristic feature of glaciated mountain landscapes. It forms when a large primary glacier erodes a deep U-shaped valley, while smaller tributary glaciers erode shallower valleys. After the ice melts, the floor of the tributary valley is left hanging" high above the main valley floor, often resulting in a waterfall where a stream flows between them.

74. (A) Marine erosion and wave action.
Coastlines are constantly reshaped by the powerful energy of ocean waves. The formation of steep cliffs, wave-cut platforms, and isolated sea stacks is a direct result of marine erosion. As waves attack a headland, they undercut the rock, creating caves and arches that eventually collapse. This leaves behind a flat rocky base and vertical pillars of more resistant rock offshore.

75. (A) 1 and 2 only
Harry Hess proposed sea-floor spreading, suggesting that new oceanic crust is continuously generated at mid-oceanic ridges and moves

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laterally. This theory successfully explained why the ocean floor is relatively young. Crucially, it also accounted for the removal of old crust at deep-sea trenches through subduction, making the third statement in the question incorrect as the theory did address these features.

76. (B) Modified Mercalli Scale
Earthquake intensity refers to the observed effects of ground shaking on people, buildings, and the natural environment at a specific location. Unlike magnitude, which measures energy release at the source, intensity is measured using the Modified Mercalli Scale. This scale uses Roman numerals to rank the severity of impact, ranging from not felt" to total destruction," based on qualitative human assessments.

77. (C) The boundaries of tectonic plates.
The global distribution of volcanoes and earthquakes is not random; rather, it is closely aligned with the edges of tectonic plates. These boundaries are zones of intense geological activity where plates collide, pull apart, or slide past one another. The resulting friction, melting, and pressure release at these margins create the vast majority of the world's seismic events and volcanic eruptions.

78. (D) Isostasy
Isostasy is the principle that explains the vertical positioning of the Earth's crust. It posits that the rigid lithosphere is in a state of buoyancy, floating upon the more plastic and denser asthenosphere. According to this concept, thicker or less dense crustal blocks, such as continents, must sit higher and extend deeper than thinner or denser blocks to maintain mechanical equilibrium.

79. (A) A basin subjected to compression and uplift after prolonged sedimentation.
The life cycle of a geosyncline begins as an elongated, subsiding trough that collects vast quantities of sediment over millions of years. This stage of accumulation is eventually followed by a period of intense tectonic compression. The lateral forces squeeze the sedimentary layers, causing them to fold and rise upward, ultimately transforming the former marine basin into a prominent mountain range.

80. (A) Both A and R are true and R is the correct explanation of A.
One of the most striking pieces of evidence for continental drift is the complementary shapes of the South American and African coastlines. Scientific analysis confirms that these landmasses were once joined as part of the supercontinent Pangaea. The similarity in their continental margins is the result of the rift that opened as the Atlantic Ocean began to form and spread.

81. (B) Transform boundary
A transform boundary occurs where two tectonic plates slide past each other in a horizontal direction. Unlike convergent or divergent boundaries, crust is neither created nor destroyed at these margins. These zones are characterized by significant friction and the accumulation of tectonic stress, which is periodically released through earthquakes, with the San Andreas Fault being a well-known continental example.

82. (A) The lowest level to which a stream can erode its valley.
The base level of erosion is a fundamental concept in fluvial geomorphology, representing the limit for vertical stream erosion. For most major rivers, the ultimate base level is the global sea level. A river cannot cut its bed below this point because it would lose the necessary gradient to flow. Local base levels, such as lakes or resistant rock, can also exist.

83. (C) Abrasion or corrasion
Potholes are circular or cylindrical depressions found in the rocky beds of fast-moving rivers. They are formed through the process of abrasion, where turbulent water swirls pebbles and sand around in a small hollow. As these abrasive materials are spun by the current, they gradually grind away the bedrock, deepening and widening the hole through continuous mechanical wear over time.

84. (D) An esker
An esker is a long, winding ridge of stratified sand and gravel. It is a depositional landform created by meltwater streams flowing through tunnels within or beneath a stagnant or retreating glacier. When the ice finally melts away, the sediment that had accumulated on the floor of these subglacial

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tunnels remains as a prominent, sinuous ridge on the post-glacial landscape.

85. (C) Ventifact
Aeolian landforms are created by the action of wind and are classified as either erosional or depositional. Sand dunes, loess, and ripples are all formed by the accumulation of wind-blown particles. A ventifact, however, is an erosional feature. It is a stone or pebble that has been polished, pitted, or faceted by the abrasive action of sand carried by the wind.

86. (B) Ample groundwater and a system of joints and fractures in the rock.
Beyond the presence of soluble limestone, Karst topography requires an active hydrological system to facilitate chemical dissolution. Ample rainfall or groundwater must be able to circulate through the rock. Therefore, a well-developed network of joints, bedding planes, and fractures is essential, as these openings provide the primary pathways for acidic water to penetrate, dissolve the rock, and create features.

87. (D) At the base of a sea cliff.
A wave-cut platform is a relatively flat, horizontal rock surface found at the shoreline. It is created as waves continuously erode the base of a sea cliff, forming a notch that eventually leads to the collapse of the overhanging rock. As the cliff retreats landward over time, this broad, rocky bench is left behind, often visible only during low tide.

88. (A) Objectively compare different landscapes and infer the processes acting upon them.
Morphometric analysis provides a quantitative framework for studying the Earth's surface. By measuring specific landform attributes like drainage density or slope steepness, scientists can move beyond simple qualitative descriptions. This objective data allows for rigorous statistical comparisons between different regions, helping to identify the dominant geological, tectonic, or climatic processes that have shaped the landscape over long periods.

89. (A) The release of progressively stored strain in rocks
The elastic rebound theory explains that earthquakes occur when tectonic forces slowly deform rocks along a fault. These rocks act like elastic bands, storing energy as they bend. Eventually, the stress exceeds the rock's strength, causing it to break and snap back to its original shape. This sudden rupture releases the accumulated strain as seismic waves, which we perceive as earthquakes.

90. (A) Divergent and convergent plate boundaries.
Volcanism is primarily concentrated at the margins of tectonic plates. At divergent boundaries, magma rises to fill the gap as plates pull apart. At convergent boundaries, especially subduction zones, the melting of a sinking plate generates magma that rises to the surface. While some volcanoes occur at hotspots, the vast majority of the world's active volcanic systems are found at these plate margins.

91. (D) Crustal blocks have varying densities but a uniform depth of compensation.
Pratt's model of isostasy differs from the Airy model by assuming that the base of all crustal blocks lies at a constant depth, known as the level of compensation. According to Pratt, the varying heights of landforms are explained by differences in their density; higher mountains are composed of lighter rocks, while low-lying plains and ocean basins consist of denser material.

92. (B) Glyptogenesis (erosion and leveling)
The cycle of a geosyncline concludes with the glyptogenesis phase, which occurs after the mountain-building orogeny. During this stage, the newly uplifted mountain range is subjected to the continuous forces of weathering and erosion. Over millions of years, these external processes wear down the high peaks and fill in remaining depressions, eventually reducing the rugged terrain to a low-relief landscape.

93. (C) The theory of plate tectonics.
Sea-floor spreading was a revolutionary concept that provided the missing mechanism for how continents could move. By showing that new oceanic crust is created at ridges and destroyed at trenches, it supported the idea of mobile plates. This discovery allowed geologists to synthesize earlier ideas like continental drift and isostasy into the comprehensive and modern theory of plate tectonics.

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94. (D) Transform fault boundary
The San Andreas Fault is one of the most famous transform boundaries in the world. It marks the zone where the Pacific Plate and the North American Plate are sliding past each other horizontally. This movement is not smooth; instead, the plates frequently lock together, accumulating stress that is periodically released as significant earthquakes, which are a defining characteristic of this tectonic boundary.

95. (A) P-2, Q-1, R-4, S-3
Glacial features are classified as either erosional or depositional based on their origin. Eskers and drumlins are depositional landforms consisting of sand, gravel, and till. Conversely, arêtes and cirques are created by the removal of rock; an arête is a sharp erosional ridge, while a cirque is a bowl-shaped hollow. Matching these terms correctly reveals the specific geological processes at work.

96. (B) Point where a river enters a standing body of water like a lake or sea.
A delta is a depositional landform that forms at the mouth of a river. When a river enters a slower-moving or stationary body of water, such as an ocean or a lake, its velocity drops abruptly. This cause the river to deposit its sediment load, which accumulates over time to form a broad, often triangular-shaped area of land that extends into the water.

97. (B) Inselberg
An inselberg is a prominent, isolated hill or small mountain that rises abruptly from a surrounding plain of low relief. These features are common in tropical and semi-arid regions and are typically composed of resistant rock like granite. They represent remnants of an ancient landscape that have survived extensive erosion while the surrounding area was worn down to a nearly flat surface.

98. (A) Maximum relief, well-integrated drainage, and the beginning of floodplain development.
In the mature stage of the Davisian cycle, the landscape reaches its point of greatest diversity. The drainage network is fully developed and well-integrated. While the vertical erosion of the youthful stage slows down, lateral erosion begins to widen valley floors, leading to the first appearance of floodplains. The difference between the highest peaks and lowest valley floors is at its maximum.

99. (C) Loess
Loess is a sediment composed primarily of wind-deposited silt that has been loosely cemented by calcium carbonate. It often forms extensive, unstratified blankets across large regions. Because loess is rich in minerals and has excellent water-retention properties, it develops into some of the world's most fertile agricultural soils, such as those found in the Loess Plateau of China and the American Midwest.

100. (B) 2 and 3 only
Karst landscapes are named after the Kras region in Slovenia and are defined by the chemical dissolution of soluble rocks like limestone, not the mechanical weathering of sandstone. A defining feature is the lack of surface water, as rain quickly drains into a complex network of underground channels. Therefore, only the second and third statements provided in the question are scientifically accurate.

101. (C) Baymouth bar
A baymouth bar is a coastal depositional feature that develops from a spit. As longshore drift continues to move sediment along the coast, the spit may eventually grow long enough to reach the headland on the opposite side of a bay. This creates a continuous ridge of sand that completely or partially blocks the bay, often forming a lagoon on the landward side.

102. (B) Drainage density
Drainage density is a fundamental morphometric parameter used to describe the efficiency of a drainage basin. It is calculated by dividing the total length of all stream channels within the basin by the basin's total area. A high drainage density indicates a landscape that is highly dissected by streams, which often reflects impermeable bedrock, sparse vegetation, or high rainfall intensity in the region.

103. (D) Epicenter
The epicenter is the specific location on the Earth's surface that lies directly above the focus, or hypocenter, where an earthquake begins. It is usually the area that experiences the strongest

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ground shaking and the most significant damage. Seismologists use the arrival times of seismic waves at different recording stations to triangulate and precisely locate the epicenter of a seismic event.

104. (A) Isostatic
Volcanic eruptions are classified based on their intensity and the nature of the ejected material. Common styles include the relatively gentle Hawaiian type, the more frequent Strombolian type, and the highly explosive Plinian type. Isostatic" is not a style of eruption; rather, it refers to the gravitational equilibrium of the Earth's crust, making it the correct choice for this non-volcanic term.

105. (C) The rising coastlines of Scandinavia after the last ice age.
Isostatic adjustment is clearly demonstrated by the vertical movement of the crust in response to loading and unloading. A prime example is observed in Scandinavia and parts of North America. After the massive continental ice sheets melted at the end of the last ice age, the underlying land began to slowly rise as it rebounded from the weight, a process that continues today.

106. (A) Folded mountain belts
The concept of a geosyncline was developed by nineteenth-century geologists to explain the origin of large-scale mountain ranges like the Appalachians and the Alps. They observed that these mountains were composed of thick layers of marine sediments. They hypothesized that these sediments first accumulated in a massive, subsiding trough before being compressed and uplifted by tectonic forces to form mountains.

107. (D) South America and Africa
One of the primary observations supporting continental drift is the remarkable geometric fit between the eastern coastline of South America and the western coastline of Africa. When these two continents are brought together on a map, they align almost perfectly, like pieces of a jigsaw puzzle. This similarity suggests they were once part of a continuous landmass before being separated by rifting.

108. (B) Mantle convection
Modern plate tectonics identifies mantle convection as the fundamental driver of plate motion. Intense heat from the Earth's core creates circulation cells within the semi-plastic mantle. As hot material rises beneath mid-oceanic ridges and cooler material sinks at subduction zones, it creates a conveyor belt" effect that exerts a dragging force on the overlying lithospheric plates, causing them to move slowly.

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109. (C) One can infer the process by studying the shape of the landform.
A central principle of geomorphology is that every natural agent, whether it be water, wind, or ice, creates distinct and recognizable landforms. By carefully analyzing the morphology, sediment types, and arrangement of a physical feature, researchers can determine the specific geomorphic processes that were responsible for its formation. This allows for the reconstruction of past environmental conditions and geological history.

110. (C) A is true but R is false.
The Pacific Ring of Fire is indeed a zone characterized by frequent earthquakes and numerous active volcanoes. However, this activity does not occur because the region is stable; rather, it is because the Ring of Fire marks the active margins of the Pacific Plate where it interacts with surrounding plates. Therefore, while the assertion is correct, the provided reason is factually incorrect.

111. (A) Rivers
Natural levees are elongated ridges of sediment that form parallel to a river channel. They are created during flood events when the river overflows its banks. As the water leaves the main channel and spreads across the floodplain, it slows down and loses energy, causing it to deposit its coarsest sediment immediately along the banks, gradually building up these protective ridges over time.

112. (B) An amphitheater-shaped hollow at a glacial valley head.
A cirque is a bowl-shaped or amphitheater-like depression carved into the side of a mountain by a glacier. It forms through the processes of frost wedging and glacial plucking at the head

of a mountain valley. Once the ice melts, these depressions are often occupied by small alpine lakes called tarns and serve as classic indicators of past mountain glaciation in the region.

113. (B) Parallel to the prevailing wind direction.
Longitudinal dunes, also known as seifs, are long sand ridges that form in areas where the wind blows from two slightly different directions or where sand is limited. These dunes are oriented parallel to the direction of the dominant prevailing wind. They can stretch for many miles across the desert and are characterized by their relatively straight or slightly sinuous appearance on the landscape.

114. (A) Solution (dissolution)
The primary process that shapes Karst topography is the chemical dissolution of soluble rocks, such as limestone or dolomite. Rainwater becomes slightly acidic as it absorbs carbon dioxide from the atmosphere and soil. As this acidic water percolates through joints and bedding planes, it reacts with the calcium carbonate in the rock, dissolving it and creating features like sinkholes, caves, and underground rivers.

115. (A) 3, 1, 2, 4
The timeline of tectonic theory began with the ancient breakup of Pangaea. In nineteen fifteen, Wegener published his landmark work on continental drift. Decades later, in nineteen sixty, Harry Hess introduced the concept of sea-floor spreading. This was followed in nineteen sixty-five by J. Tuzo Wilson's introduction of transform faults, which provided a critical missing component to the unified theory of plate tectonics.

116. (D) Sea stack
Coastal landforms are divided into erosional and depositional categories. Beaches, tombolos, and barrier islands are all built through the accumulation of sediment. A sea stack, however, is a product of erosion. it is an isolated vertical pillar of rock that remains after a headland has been eroded by waves, leaving the more resistant portion standing alone in the ocean near the shore.

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117. (C) Stream segments of consecutive orders.
The bifurcation ratio is a key parameter in morphometric analysis that describes the branching pattern of a drainage network. It is the ratio of the number of stream segments of a given order to the number of segments in the next higher order. This ratio remains relatively constant for a given region and provides insights into the geological structure and flood potential of a basin.

118. (B) The crust and the mantle.
The Mohorovičić discontinuity, commonly called the Moho, is a major internal boundary within the Earth. It marks the transition where seismic waves significantly increase in velocity as they move from the lighter rocks of the crust into the denser, ultramafic rocks of the upper mantle. This boundary is found at varying depths, being much shallower under oceans than under continental mountain ranges.

119. (D) Active
Volcanoes are classified based on their current state of eruptive activity. An active volcano is one that is currently erupting, shows signs of unrest like seismic activity or gas emissions, or has erupted in recent historical times. This distinguishes it from dormant volcanoes, which are currently quiet but expected to erupt again, and extinct volcanoes, which are considered unlikely to ever erupt in the future.

120. (A) The proposed tidal forces were shown to be far too weak.
F.B. Taylor's early theory of continental drift was rejected by the scientific community primarily due to the lack of a plausible driving mechanism. He suggested that tidal forces from the Moon were responsible for pulling continents across the Earth's surface. However, physicists demonstrated that tidal forces are far too weak to overcome the friction and strength of the crust, leading to the theory's dismissal.

121. (C) Subduction
Subduction is a fundamental process in plate tectonics that occurs at convergent boundaries. It involves one lithospheric plate, typically a denser oceanic plate, being forced downward into the mantle beneath an adjacent, less dense plate. This process is responsible for the formation of

deep-sea trenches, the recycling of oceanic crust, and the generation of powerful earthquakes and explosive volcanic activity along the boundary.

122. (A) Peneplain
A peneplain is a broad, low-relief plain that represents the final stage of the Davisian cycle of erosion. According to the theory, after millions of years of continuous weathering and fluvial erosion, a highland region is eventually worn down to a nearly flat surface near sea level. The landscape is characterized by sluggish, meandering streams and a lack of significant topographic variation across the terrain.

123. (D) Oxbow lake
An oxbow lake is a crescent-shaped body of water formed when a wide meander of a river is cut off from the main channel. This typically occurs during a flood when the river finds a shorter, straighter path across the narrow neck of the meander. Once the ends of the old loop are filled with silt, it becomes an isolated, stagnant lake on the floodplain.

124. (B) Large-scale scouring of the landscape and deposition of till sheets
Continental glaciation involves massive ice sheets covering vast areas, such as during an ice age. Its primary impact is the large-scale modification of the terrain through the scouring of bedrock and the widespread deposition of unsorted sediments known as till. This process creates broad features like outwash plains and ground moraines, rather than the localized ridges and valleys typical of smaller mountain glaciers.

125. (C) P-4, Q-2, R-3, S-1
Wegener's theory of continental drift describes the evolution of landmasses through geological time. Pangaea was the original supercontinent, entirely surrounded by the vast Panthalassa ocean. Upon its initial fragmentation, the northern section became Laurasia, while the southern part formed Gondwanaland. The Tethys Sea eventually opened as a shallow marine waterway between these two massive land segments, separating the northern and southern landmasses.

126. (D) Wind-driven sand
A ventifact is a rock or pebble that has been shaped and modified by the abrasive action of wind-blown sand. In arid environments, the wind carries abrasive particles that act like a sandblaster, grinding down the windward side of rocks. This process creates smooth, polished facets and sharp edges on the rock surface, providing a clear indication of the prevailing wind direction in the area.

127. (A) Drumlins
Karst topography is defined by the chemical dissolution of limestone, resulting in features like sinkholes, caves, and disappearing streams. These landforms are created by acidic groundwater. In contrast, drumlins are streamlined hills composed of glacial till, which are depositional features created by the movement of ice sheets. Therefore, drumlins are associated with glacial geomorphology and are not found in characteristic Karst landscapes.

128. (B) Longshore drift
Longshore drift is a geological process that involves the transport of sediment, such as sand and gravel, along a coastline. It occurs when waves approach the shore at an angle, pushing sediment up the beach in a diagonal direction. As the water recedes straight back, it carries the sediment directly down the slope, resulting in a net movement of material parallel to the shore.

129. (B) Underlying rock structure and topography.
The arrangement and orientation of a drainage network are heavily influenced by the nature of the terrain. Different drainage patterns, such as dendritic or trellis, reflect variations in rock resistance, the presence of faults or folds, and the overall slope of the land. By studying these patterns, geomorphologists can infer the underlying geological structure and reconstruct the tectonic history of a specific region.

130. (A) P-wave shadow zone
The P-wave shadow zone is a region on the Earth's surface between approximately one hundred five and one hundred forty degrees from an earthquake's epicenter where direct P-waves are not detected. This phenomenon occurs because P-waves are bent or refracted as they pass from the solid mantle into the liquid outer core. The existence of this zone provided early scientific evidence of the Earth's internal layering.

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131. (C) The margins of tectonic plates.
The global distribution of volcanoes is remarkably consistent with the boundaries of tectonic plates. These margins, particularly subduction zones and mid-oceanic ridges, are areas where magma can easily reach the Earth's surface. The movement and interaction of plates create the necessary conditions of heat and pressure for volcanism, resulting in concentrated belts of activity like the famous Pacific Ring of Fire.

132. (D) The measurement of gravity anomalies over mountains and plains.
Isostasy is scientifically supported by the study of gravity anomalies. Precise measurements show that large mountain ranges exert less gravitational pull than expected based on their visible mass. This discrepancy is explained by the presence of low-density roots" beneath the mountains that displace denser mantle material. These findings confirm that the Earth's crust is in a state of gravitational balance, floating in the mantle.

133. (C) Pole-fleeing force and tidal force
Alfred Wegener proposed that the continents moved across the Earth's surface driven by two main forces. The pole-fleeing force" was thought to result from the Earth's rotation and centrifugal force, pushing landmasses toward the equator. Additionally, he suggested that the tidal attraction of the Sun and Moon exerted a dragging force on the continents. Both mechanisms were later proven to be insufficient for moving plates.

134. (B) A major non-volcanic mountain range
When two continental plates collide, their similar densities prevent subduction into the mantle. Instead, the crustal material is forced upward and thickened, resulting in the formation of massive, non-volcanic mountain ranges. The collision between the Indian and Eurasian plates, which created the Himalayas, is the most prominent example of this process, characterized by intense folding, faulting, and significant crustal thickening.

135. (C) 1 and 3 only
Streams and wind create various landforms through erosion and deposition. A gorge is an erosional feature formed by rapid river downcutting, while a barchan is a sand dune created by wind deposition. However, a cirque is not a depositional feature; it is an erosional hollow carved into a mountain by a glacier. Therefore, only the first and third statements in the provided question are correct.

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136. (A) Solifluction
Solifluction is a specific type of mass wasting that occurs in periglacial or high-altitude environments characterized by permafrost. During the summer, the upper layer of soil thaws and becomes saturated with water because it cannot drain into the frozen ground below. This water-logged soil loses its stability and slowly flows downslope, even on gentle gradients, creating distinctive lobe-shaped features on the landscape.

137. (C) Braided river
A braided river is characterized by a network of small, shallow channels that divide and reunite around temporary bars and islands. This pattern develops in rivers with a high sediment load and variable water discharge. Because the river cannot transport all its sediment, it frequently chokes its own channel, forcing the water to divert and create the intricate, interlaced appearance typical of braided systems.

138. (A) Sorted sand and gravel deposited by meltwater.
Kames and eskers are both fluvio-glacial landforms created by the action of meltwater associated with glaciers. Unlike till, which is unsorted material deposited directly by ice, the sediment in these features is sorted and stratified. This occurs because moving water carries and deposits particles of similar size together, building up these mounds and ridges of sand and gravel during glacial retreat.

139. (D) Aeolian abrasion
A mushroom rock, also known as a pedestal rock, is a landform typical of desert environments. It is formed by the abrasive action of wind-blown sand. Because sand grains are heavy, they are transported primarily near the ground surface. Consequently, the lower portion of an isolated rock is eroded more rapidly than the top, eventually resulting in a structure with a narrow base and wider top.

140. (B) Parts of Southern China and Vietnam
Tower karst is a spectacular landscape characterized by steep-sided, isolated limestone hills that rise vertically from a surrounding flat plain. This advanced stage of Karst development results from intense chemical weathering and tropical rainfall. The most famous examples of this topography are found in the Guilin region of Southern China and the Ha Long Bay area of Vietnam, where the peaks create a dramatic scenery.

141. (C) Headland
A sea arch is a transitional erosional landform created along rocky coastlines. As waves attack a headland, they initially form sea caves on both sides. Through continuous erosion, these caves may eventually meet and break through, creating an arch. Over time, the roof of the arch will weaken and collapse, leaving an isolated pillar of rock known as a sea stack standing offshore.

142. (D) Distribution of area with respect to elevation in a drainage basin.
Hypsometric analysis is a morphometric technique used to study the relationship between horizontal area and vertical elevation within a drainage basin. It is typically expressed as a hypsometric curve or integral. This analysis provides valuable information about the stage of landscape evolution, the degree of tectonic activity, and the overall erosional state of a basin, allowing geomorphologists to characterize its maturity.

143. (A) Mantle and Core
The Gutenberg Discontinuity is a significant boundary within the Earth's interior, located at a depth of approximately two thousand nine hundred kilometers. It marks the transition from the solid, silicate-rich mantle to the liquid, metallic outer core. This boundary is identified by the abrupt change in seismic wave behavior, specifically the dramatic slowing of P-waves and the complete disappearance of S-waves.

144. (B) Orogenic uplift
In the traditional theory of geosynclines, the process of subsidence is driven by factors like sediment loading, crustal thinning, or thermal changes. These processes cause the basin floor to sink over millions of years. Orogenic uplift, however, is the opposite process. It occurs during the mountain-building phase when compressional forces squeeze and lift the accumulated sediments upward, marking the end of the subsiding basin stage.

145. (A) Both A and R are true and R is the correct explanation of A.
The Himalayas are a young and geologically active mountain range. Their continuous uplift is a direct result of the ongoing plate tectonic collision between the Indian and Eurasian plates. Because the Indian plate continues to move northward at a rate of several centimeters per year, it maintains intense pressure on the boundary, causing the mountains to keep rising and triggering frequent earthquakes.

146. (A) Volcanic cone
A radial drainage pattern develops when streams flow outward in all directions from a central high point. This pattern is most commonly found on isolated, symmetrical mountain peaks like volcanic cones or structural domes. The streams radiate from the summit toward the base, much like the spokes of a wheel, reflecting the uniform outward slope of the landform from its central highest elevation.

147. (C) A main glacier erodes much deeper than tributary glaciers.
A hanging valley is a characteristic glacial landform. During a period of glaciation, a massive main-trunk glacier erodes a much deeper U-shaped valley than the smaller tributary glaciers feeding into it. When the ice eventually melts, the floor of the tributary valley is left stranded high above the main valley floor. This often results in the formation of waterfalls as streams drop between them.

148. (D) Natural Levee
Glacial depositional features include moraines, which are ridges of till; drumlins, which are streamlined hills; and eskers, which are sinuous ridges of sand and gravel. These are all formed by the movement and melting of ice. A natural levee, however, is a fluvial landform. It is a ridge of sediment deposited by a river along its banks during flood events, unrelated to glacial processes.

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149. (C) Thick limestone bedrock, high rainfall, and a deep water table.
The optimal development of Karst topography requires several specific environmental conditions. A thick layer of soluble limestone provides the necessary material for dissolution. High rainfall ensures an ample supply of water to react with carbon dioxide and dissolve the rock. A deep water table allows for extensive vertical circulation of groundwater, facilitating the creation of large cave systems and significant subsurface drainage features.

150. (B) Landslides are rapid movements, while soil creep is very slow.
Mass wasting events are primarily distinguished by their velocity and the nature of the movement. Soil creep is a nearly imperceptible and continuous downward movement of soil that occurs over many years. In contrast, landslides are characterized by the sudden and rapid displacement of a coherent mass of rock or debris. This difference in speed is crucial for assessing geological hazards and implementing stabilization measures.

151. (D) The Himalayan region and Northeast India
Seismic zonation in India categorizes regions based on their historical seismic activity and tectonic vulnerability. Zone five denotes the highest risk level, encompassing areas where the most intense ground shaking is anticipated. This zone specifically includes the Himalayan belt and northeastern states, where the ongoing convergent movement of the Indian and Eurasian plates frequently triggers significant and potentially damaging earthquake events.

152. (A) Thermoremanent magnetization
Thermoremanent magnetization is a process where igneous rocks acquire a permanent record of the Earth's magnetic field as they cool. When minerals like magnetite reach their Curie temperature, they align themselves with the prevailing magnetic poles. This fixed orientation is preserved as the rock solidifies, providing a frozen" magnetic record that allows scientists to reconstruct the historical positions of plates and study field reversals.

153. (C) Lithospheric plates
Plate tectonics is built on the concept that the Earth's rigid outer shell is not a single piece. Instead, the lithosphere is divided into several large and small slabs called plates. These plates float on the more plastic asthenosphere and move relative to one another. Their interactions at boundaries drive major geological processes, including mountain building, volcanic activity, and the formation of ocean basins.

154. (A) Old Age
In the final stage of the Davisian cycle, known as old age, the landscape has been worn down to a nearly flat plain called a peneplain. The original mountains have been almost entirely removed by erosion. The only significant topographic features remaining are isolated hills composed of more resistant rock that have survived the leveling process. These remnant hills are often referred to as monadnocks.

155. (D) Youthful stage
Waterfalls and rapids are characteristic features of a river in its youthful stage. During this period, the river has a steep gradient and high energy, which it uses to actively cut into its bed. These features often form where the river flows over alternating layers of hard and soft rock. As the river matures and achieves a more balanced profile, these turbulent features are gradually removed.

156. (B) Meltwater streams flowing from the terminus of a glacier.
An outwash plain is a broad, gently sloping area composed of stratified sand and gravel. It is a depositional landform created by the action of meltwater streams flowing away from the front of a retreating glacier. As the water leaves the ice, it spreads out and slows down, depositing its sediment load. These plains are often characterized by braided stream patterns and extensive sorted deposits.

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157. (C) Abrasion
Abrasion is a mechanical erosional process where the wind uses particles it is carrying, such as sand, to grind and scrape against rock surfaces. Much like sandblasting, this continuous impact of abrasive grains can polish, pit, and facet rocks. Over long periods, abrasion can create

unique landforms like ventifacts and yardangs, particularly in arid regions where the wind is a dominant geomorphic agent.

158. (D) Caves
Stalactites and stalagmites are speleothems, which are mineral deposits formed by the precipitation of calcium carbonate from dripping water. These features are found exclusively in limestone caves. Stalactites grow downward from the ceiling, while stalagmites build upward from the floor. Over thousands of years, these deposits can grow to be several meters long, sometimes meeting to form solid columns within the cave system.

159. (A) Geomorphology
Geomorphology is the scientific discipline dedicated to the study of the Earth's surface features. It investigates the physical form, size, and geometry of diversos landforms and the processes that create them. By analyzing the interaction between internal tectonic forces and external agents like water and wind, geomorphologists seek to understand the origin and evolution of the landscape throughout geological time.

160. (B) P-4, Q-3, R-2, S-1
The history of geology is defined by several influential theories and their proponents. W.M. Davis is famous for the Cycle of Erosion model. Alfred Wegener introduced the ground breaking theory of Continental Drift. Harry Hess provided the mechanism of Sea Floor Spreading. George Airy developed an isostasy model based on the idea of mountain roots. Correctly matching these scientists with their concepts clarifies key developments.

161. (B) The release of pressure on superheated magma, allowing gases to expand.
Volcanic eruptions are primarily driven by the expansion of dissolved gases within magma. As magma rises toward the surface, the weight of the overlying rock decreases, causing a drop in pressure. This allows gases like water vapor and carbon dioxide to rapidly expand and form bubbles. If the pressure becomes high enough, it forces the magma out of the vent, resulting in an eruption.

162. (A) The formation of mid-oceanic ridges.
Isostasy explains the vertical balance of the crust, such as the uplift of land after glaciation or the presence of roots beneath mountains. It also accounts for subsidence in sediment-heavy regions like deltas. However, the formation of mid-oceanic ridges is driven by lateral plate divergence and mantle upwelling, which are tectonic processes related to sea-floor spreading rather than the simple gravitational equilibrium of isostasy.

163. (C) The existence of the supercontinent Gondwanaland.
The discovery of Glossopteris fossil flora provided critical evidence for continental drift. This ancient seed fern lived during the Permian period and its fossils have been found across South America, Africa, India, Antarctica, and Australia. Because the seeds were too large to be carried by wind across oceans, their widespread distribution suggests these continents were once part of a single supercontinent called Gondwanaland.

164. (D) Seas are smaller and partially enclosed by land.
While both are large bodies of saltwater, seas and ocean basins are distinguished by their size and geography. Ocean basins are massive, deep features that cover the majority of the Earth's surface. In contrast, seas are smaller, shallower, and are typically located where the ocean meets the land, often being partially surrounded or enclosed by continental masses or island chains.

165. (C) Rifting and the formation of new crust
At a divergent plate boundary, tectonic plates are pulling apart from each other. This movement causes the lithosphere to thin and fracture, creating a rift. As the plates separate, magma rises from the mantle to fill the gap. This magma cools and solidifies, resulting in the continuous generation of new oceanic crust and the formation of features like mid-oceanic ridges and rift valleys.

166. (B) A region of folded or tilted sedimentary rocks with varying resistance.
A trellis drainage pattern is a strong indicator of structural control in the landscape. It develops in areas where sedimentary rock layers have been folded into parallel ridges and valleys. The main

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streams flow along the valleys of softer rock, while short tributaries join at right angles from the slopes of more resistant ridges, creating a layout that resembles a garden trellis.

167. (D) Glacial erosion.
U-shaped valleys are classic landforms produced by glacial erosion. As a massive glacier moves through a pre-existing V-shaped river valley, it scours the bottom and sides with immense force. The processes of abrasion and plucking widen the valley and steepen its walls. This results in a broad, flat-bottomed valley with a characteristic U" shape, marking the former path of a mountain glacier.

168. (A) Their horns point upwind, often anchored by vegetation.
Parabolic dunes are distinct from barchans in both their shape and the conditions under which they form. While barchans have horns pointing downwind, the horns of a parabolic dune point into the wind. These dunes often form in coastal areas or semi-arid regions where vegetation partially stabilizes the sand, allowing only the center of the dune to migrate forward, creating the U-shape.

169. (C) A large, flat-floored, closed depression.
A polje is the largest type of closed depression found in Karst landscapes. It is a broad, flat-bottomed basin that can extend for many kilometers. Poljes form through a combination of tectonic faulting and the chemical dissolution of limestone. They often have a complex drainage system, with surface streams that enter the basin and then disappear into underground channels called ponors.

170. (D) 1, 2 and 3
Geomorphology uses specific terms to describe the natural agents that shape the Earth's surface. Fluvial processes are those related to moving water in rivers and streams. Aeolian processes involve the action of wind, particularly in arid regions. Glacial processes refer to the work of moving ice. Since all three definitions provided in the question are correct, they accurately reflect the terminology of the field.

171. (D) Forms a sandy ridge across the entrance to a bay.
A baymouth bar is a coastal depositional feature that originates as a spit. Through the continuous process of longshore drift, sand and gravel are transported along the shore and deposited. If the spit grows long enough to completely span the opening of a bay, it becomes a bar. This feature effectively isolates the bay from the open ocean, often creating a calm lagoon.

172. (A) Outer core and inner core.
The Lehmann discontinuity is a major internal boundary within the Earth's core, located at a depth of about five thousand one hundred fifty kilometers. It separates the liquid outer core from the solid inner core. This boundary was discovered through the analysis of seismic waves, which showed a significant increase in velocity, indicating a transition to a much denser and more rigid metallic material.

173. (C) A stationary plume of hot material rising from deep within the mantle.
Hotspot volcanism is unique because it occurs away from tectonic plate boundaries. It is caused by mantle plumes, which are columns of exceptionally hot material rising from deep within the Earth. As a tectonic plate moves slowly over a stationary hotspot, a sequence of volcanoes is formed. This process created the Hawaiian-Emperor seamount chain, where the age of the islands increases with distance.

174. (D) The movement of continents relative to fixed magnetic poles.
Polar wandering was once thought to be the physical movement of the magnetic poles. However, scientific evidence from paleomagnetism showed that different continents recorded different paths for the poles. The only logical explanation is that the poles remained relatively fixed while the continents moved independently over time. This discovery provided a critical independent confirmation for the theory of continental drift and plate motion.

175. (A) The subduction of the Nazca plate beneath the South American plate.
The Andes Mountains represent a classic example of an oceanic-continental convergent boundary. The denser Nazca oceanic plate is

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being subducted beneath the less dense South American continental plate. This process leads to intense folding of the continental margin, high-magnitude earthquakes, and the generation of magma that feeds a chain of explosive volcanoes along the entire length of the mountain range.

176. (B) A river that is able to maintain its course by cutting through a slowly uplifting mountain range.
An antecedent drainage system occurs when a river established its course before the uplift of a mountain range. As the land slowly rises due to tectonic forces, the river has enough erosional energy to cut through the rising rock at the same rate as the uplift. This allows the river to maintain its original path, resulting in deep, narrow gorges that cross the mountains.

177. (B) Farthest point of advance of a glacier.
A terminal moraine is a depositional landform consisting of an unsorted ridge of glacial till. It forms at the snout or terminus of a glacier when it remains stationary for a period of time. The ice acts like a conveyor belt, continuously bringing debris to the edge and depositing it. This ridge marks the maximum extent to which the glacier advanced before retreating.

178. (A) Variable wind directions.
Star dunes are complex sand dunes that are characterized by a central high peak with several radiating ridges, resembling a star. These dunes form in desert regions where the wind directions are highly variable and blow from multiple different quarters. The shifting winds prevent the formation of simpler dune shapes like barchans, instead building up the sand into these large, stationary, and multi-directional features.

179. (C) Karst
Disappearing streams are a hallmark feature of Karst topography. In these regions, the soluble nature of the limestone bedrock allows surface water to dissolve pathways into the ground. A stream may flow on the surface for some distance and then suddenly vanish into a sinkhole or a fracture in the rock. The water then continues its flow through an intricate network of underground caverns and channels.

180. (A) Both A and R are true and R is the correct explanation of A.
Karst regions often lack a traditional surface drainage network because the bedrock, typically limestone, is highly soluble. Slightly acidic rainwater dissolves the rock along joints and bedding planes, creating vertical pathways. Consequently, surface water is quickly diverted into these underground systems. This process leaves the surface dry and leads to the development of caves and other subterranean features characteristic of Karst terrain.

181. (C) Barrier island
A barrier island is a long, narrow offshore landform composed of sand and sediment. It sits parallel to the main coastline and is separated from it by a shallow lagoon or sound. These islands protect the mainland from the direct impact of high-energy ocean waves. They are dynamic features, constantly being reshaped by the forces of waves, tides, and longshore currents over geological time.

182. (B) Geomorphic processes operate independently of the geologic structure.
A fundamental principle of geomorphology is that geologic structure is a dominant control on landform development. The type of rock, its resistance to erosion, and the presence of folds or faults largely determine the resulting shape of the landscape. Therefore, geomorphic processes do not operate independently; rather, they interact with the underlying geology to produce the distinctive features we observe on the Earth's surface.

183. (D) The point within the Earth where the fault rupture originates.
The focus, also known as the hypocenter, is the exact point in the Earth's interior where an earthquake begins. It is the location on a fault plane where the initial rupture occurs and the accumulated tectonic energy is first released. Seismic waves radiate outward in all directions from this point, traveling through the Earth's layers before eventually reaching the surface at the epicenter.

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184. (A) The rigid outer layer of the Earth, consisting of the crust and upper mantle.
The lithosphere is the cool, rigid outermost shell of the Earth. It includes the entire crust and the very uppermost portion of the mantle. This layer is broken into several large tectonic plates that move over the more plastic asthenosphere below. The physical properties of the lithosphere allow it to fracture and generate earthquakes when subjected to tectonic stresses at plate boundaries.

185. (C) Geographic location relative to continents and oceans.
In traditional geological theory, geosynclines were classified based on their proximity to continental margins. Miogeosynclines were situated on the stable continental side and lacked volcanic material. Eugeosynclines were located further offshore, in deeper water, and were characterized by significant volcanic activity. This classification helped scientists understand the different environments in which thick sedimentary sequences were deposited before being transformed into mountain ranges.

186. (A) Continental drift.
Sea-floor spreading provided the essential physical mechanism that Alfred Wegener's original theory of continental drift lacked. By demonstrating that new oceanic crust is continuously generated at mid-oceanic ridges, it showed how ocean basins could widen and push continents apart. This discovery transformed the idea of drifting continents from a speculative hypothesis into a scientifically grounded component of the broader theory of plate tectonics.

187. (D) Continental-Continental
The ongoing collision between the Indian Plate and the Eurasian Plate is a classic example of a continental-continental convergent boundary. Because both plates are made of relatively light continental crust, neither can be easily subducted into the mantle. Instead, the crust between them is intensely folded, faulted, and squeezed upward, resulting in the massive thickening of the crust and the formation of the Himalayas.

188. (B) Attrition
Attrition is a fluvial erosional process that occurs within the sediment load carried by a river. As the water moves, particles of sand and rock collide with each other. These continuous impacts cause the particles to break into smaller fragments and become smoother and more rounded over time. Unlike abrasion, which wears down the riverbed, attrition specifically reduces the size of the transported sediment itself.

189. (C) Horn
A horn is a sharp, pyramid-shaped mountain peak formed by glacial erosion. It is created when several glaciers erode the head walls of their respective cirques toward the same central point from different sides of a mountain. This multi-directional head ward erosion thins the dividing ridges and sharpens the summit into a jagged, angular peak, with the Matterhorn in the Alps being the most famous example.

190. (A) 1, 2, 3
Geomorphic agents vary in their ability to sort sediment by size. Wind is the most effective sorter, as it can only carry fine grains like sand and silt over long distances. Water is moderately effective, depositing sediment as its velocity changes. Glaciers are the least effective, as they carry everything from fine clay to massive boulders together and deposit them as an unsorted mixture called till.

191. (A) A layer of loose, weathered rock and mineral fragments covering bedrock.
Regolith is the layer of unconsolidated material that covers the solid bedrock of the Earth's surface. it is formed through the processes of physical and chemical weathering. Regolith includes soil, loose rock fragments, and volcanic ash. This layer is of great importance as it supports plant life, stores groundwater, and serves as the raw material from which true soil is eventually developed.

192. (B) Beach
A beach is a classic example of a marine depositional landform. It consists of an accumulation of sand, gravel, or pebbles along a coastline. Beaches form where wave energy is low enough to allow sediment to settle. The material is often transported to the site by longshore drift or brought in from offshore. In contrast, cliffs, platforms, and caves are all created through erosional processes.

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193. (B) Quantitative and objective approach to describing landforms.
The primary value of morphometric analysis lies in its use of mathematical data to describe the landscape. By calculating ratios and measuring specific dimensions like slope or drainage density, it removes the subjectivity of qualitative descriptions. This quantitative approach allows scientists to make objective comparisons between different geographical areas and to model the complex relationships between tectonic forces, climate, and the resulting physical features of the Earth.

194. (A) S-waves cannot travel through the liquid outer core.
The S-wave shadow zone is much larger than the P-wave shadow zone because of a fundamental property of shear waves. S-waves require a rigid medium to propagate and cannot travel through liquids. When they encounter the Earth's liquid outer core, they are completely blocked. This creates a massive shadow" on the opposite side of the planet, covering more than one hundred degrees of the Earth's surface.

195. (C) An explosive eruption and a stratovolcano.
Magma with a high silica content is characterized by high viscosity, meaning it does not flow easily. This thick magma tends to trap volcanic gases, allowing pressure to build up to extreme levels. When the pressure is finally released, it results in a violent, explosive eruption. These types of eruptions typically build steep-sided, conical mountains known as stratovolcanoes or composite volcanoes, which are composed of alternating layers.

196. (D) Isostatic response
Isostasy is the principle of gravitational balance in the Earth's crust. When erosion removes a significant amount of weight from a mountain range, the underlying crust becomes more buoyant. To maintain equilibrium, the crust rises upward in an isostatic response. This process ensures that mountains continue to sit high even as they are worn down, demonstrating the dynamic vertical adjustment of the lithosphere in the mantle.

197. (C) Geosynclinal
Plate tectonics identifies three primary types of boundaries based on the relative motion of the plates: convergent, where they collide; divergent, where they separate; and transform, where they slide past each other. Geosynclinal" is an older term from a historical theory of mountain building and does not represent a type of plate boundary in modern tectonic theory, although it describes a subsiding basin environment.

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198. (B) Rejuvenation
Rejuvenation occurs when a river that has reached a mature or old age stage is given a sudden increase in erosional energy. This is usually caused by a tectonic uplift of the land or a fall in sea level, which increases the river's gradient. As a result, the river begins to cut vertically into its bed again, creating features like incised meanders and river terraces.

199. (D) Remnant of a former floodplain now at a higher elevation than the current river.
A river terrace is a flat, bench-like landform located along the side of a river valley. It represents the remnant of an older floodplain from a time when the river flowed at a higher elevation. Terraces form when a river is rejuvenated and begins to cut down into its own deposits, leaving the old valley floor stranded above the new, lower river level.

200. (B) P-3, Q-4, R-2, S-1
Aeolian landforms are shaped by the action of wind through erosion and deposition. Barchans are crescent-shaped sand dunes. Yardangs are elongated ridges sculpted by abrasion. Loess consists of blankets of wind-deposited silt. Ventifacts are stones that have been faceted and polished by wind-blown particles. Correctly matching these terms demonstrates an understanding of how wind processes create diverse and distinctive features in arid environments.

201. (C) Pacific Ocean
The Ring of Fire" is a major geographic zone rimming the Pacific Ocean basin. It is characterized by nearly continuous belts of oceanic trenches, volcanic island arcs, and plate boundaries. This region contains a vast majority of the world's active volcanoes and experiences

frequent, high-magnitude earthquakes, reflecting the intense tectonic activity as the Pacific Plate interacts with several surrounding lithospheric plates.

202. (A) Mass deficiency below.
The concept of isostasy implies that the Earth's crust is in gravitational equilibrium. To support a large visible mass at the surface, such as a mountain, there must be a corresponding mass deficiency beneath it. This deficiency is usually in the form of a root" of lighter crustal material that extends into the denser mantle, providing the buoyancy necessary to keep the mountain afloat.

203. (D) Meteorology and Climatology
Alfred Wegener, the father of the continental drift theory, was not a geologist by training. He was a German meteorologist and climatologist. His diverse background allowed him to integrate evidence from various fields, such as matching ancient climates across now-separated continents, to support his groundbreaking hypothesis. His scientific perspective was instrumental in challenging the established geological views of his time regarding fixed continents.

204. (B) A deep oceanic trench.
A subduction zone is a convergent boundary where one plate sinks beneath another. As the sinking plate bends and descends into the mantle, it creates a long, narrow, and exceptionally deep depression on the ocean floor known as a trench. These trenches are the deepest parts of the world's oceans and are always associated with intense seismic activity and explosive volcanism on the overriding plate.

205. (C) The present is the key to the past."
Uniformitarianism is the guiding principle of modern geology, famously summarized by the phrase The present is the key to the past." It suggests that the same physical, chemical, and biological processes that operate on the Earth today have operated in a similar manner throughout geological time. By studying modern processes, scientists can accurately interpret and explain the origin of ancient rock formations and landscapes.

206. (D) Gorge
Fluvial landforms are categorized as either erosional or depositional. Deltas, alluvial fans, and point bars are all built by the accumulation of sediment transported by water. A gorge, however, is an erosional feature. it is a deep, narrow, and steep-sided valley that is formed when a river rapidly cuts vertically into its bed, often during the youthful stage of its development or following rejuvenation.

207. (A) Unsorted, unstratified debris deposited directly by glacial ice.
Glacial till is a type of sediment that is deposited directly by melting ice. Because it is not transported by water, it is not sorted by size or layered. Till consists of a random mixture of particles ranging from fine clay and silt to massive boulders. The presence of till on the landscape is a primary piece of evidence for the former presence of a glacier in the area.

208. (B) Carbonation of calcium carbonate
The development of Karst topography is driven by a chemical process called carbonation. Rainwater absorbs carbon dioxide from the air and soil to form a weak carbonic acid. This acidic water reacts with the calcium carbonate in rocks like limestone, converting it into soluble calcium bicarbonate. The rock is then dissolved and carried away in solution, creating the characteristic sinkholes and cave systems.

209. (B) Rias and fjords (drowned valleys).
When the global sea level rises or the land subsides, existing coastal valleys are flooded by the ocean. This process creates distinctive drowned" landforms. A ria is a flooded river valley, characterized by a dendritic or branching shape. A fjord is a drowned U-shaped glacial valley with steep sides. Both features provide clear evidence of a relative rise in sea level across a coastal region.

210. (A) 1 and 2 only
The theory of plate tectonics describes the lithosphere as being divided into several rigid plates that are in constant, slow motion. Most significant geological activity, including the majority of earthquakes, is concentrated along the boundaries of these plates. However, continents are not separate from the plates; they

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are thick, buoyant parts of the lithospheric plates themselves, making the third statement provided incorrect.

211. (C) The river building up its bed with sediment.
Aggradation is a fluvial process where a river deposits more sediment than it can transport. This occurs when the river's energy decreases, such as due to a drop in gradient or a decrease in water volume. Over time, the accumulated sediment builds up the riverbed, increasing its elevation. This process is common in braided streams and on floodplains, often leading to the formation of natural levees.

212. (D) An exposed rock peak or summit not covered with ice within a glacier or ice sheet.
A nunatak is a prominent geological feature found in glaciated environments. It is a ridge or mountain peak that remains exposed above the surface of an ice sheet or glacier. While the surrounding landscape is completely buried in ice, the nunatak sticks out as a rocky island. These features are common in Greenland and Antarctica and often serve as important refuges for local plants and animals.

213. (C) Dunes are made of sand, loess is made of silt.
Both sand dunes and loess are depositional landforms created by the action of wind, but they differ primarily in the size of the particles they contain. Sand dunes are composed of relatively coarse sand grains that are transported primarily through saltation. Loess, on the other hand, consists of much finer silt and clay particles that can be carried in suspension over much greater distances before settling.

214. (B) Sinkhole
A doline is the scientific term used in geomorphology to describe a sinkhole. It is a closed, bowl-shaped depression in the ground surface typical of Karst landscapes. Dolines form either through the slow chemical dissolution of limestone at the surface or the sudden collapse of a cave roof. They serve as primary conduits for surface water to enter the underground drainage system in limestone regions.

215. (D) The action of swash and backwash.
The movement of sand along a beach is driven by the interaction of waves with the shore. When a wave breaks, the swash moves sediment up the beach at an angle. As the water recedes, the backwash carries it directly down the slope. This continuous zig-zag motion, known as beach drift, results in the net transport of sand parallel to the coastline over time.

216. (A) The point at which a system is forced to change, often abruptly, due to a change in conditions.
In geomorphology, a threshold represents a limit of stability in a natural system. When a landscape process or landform is pushed beyond this critical point, it undergoes a rapid and fundamental change. For example, a river bank may remain stable until a specific flood intensity is reached, at which point it suddenly collapses. Understanding these thresholds is essential for predicting how landscapes respond to environmental changes.

217. (C) A developing divergent plate boundary.
The East African Rift Valley is a modern geological laboratory showing the early stages of a divergent plate boundary. Tectonic forces are pulling the African Plate apart, causing the crust to thin and drop down between large faults. This process is accompanied by significant volcanic activity and shallow earthquakes. Over millions of years, this rift may eventually widen enough to form a new ocean basin.

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218. (A) On the continental side, lacking intense volcanic activity.
In the classic geosynclinal theory, a miogeosyncline is the part of a geosynclinal couple that is located closer to the stable continental interior. It is characterized by relatively shallow water and the accumulation of thick sequences of sediments like limestone and sandstone. Crucially, miogeosynclines lack the volcanic material and intense tectonic activity that are typically associated with the more offshore eugeosynclines.

219. (D) A wide floodplain, meanders, and oxbow lakes.
The old age stage of a river cycle is reached when the landscape has been eroded to a nearly flat surface near base level. The river has a very low gradient and slow velocity. Its primary work is lateral erosion and deposition on a broad floodplain. The channel is characterized by large,

sweeping meanders, frequent course changes, and the presence of numerous oxbow lakes and natural levees.

220. (A) Both A and R are true and R is the correct explanation of A.
Mid-oceanic ridges are sites of continuous tectonic activity. As plates pull apart at these divergent boundaries, the lithosphere is stretched and thinned, leading to the formation of normal faults. Because the rising magma keeps the crust hot and thin, the resulting earthquakes occur at very shallow depths. These seismic events are a direct consequence of the crustal extension and volcanic processes occurring at the ridge.

221. (C) On the inner bank of a meander.
A point bar is a fluvial depositional landform. In a meandering river, the water flows more slowly on the inside of a curve. This decrease in velocity causes the river to deposit its sediment load, typically sand and gravel, along the inner bank. Over time, these deposits build up to form a gently sloping bar that grows outward, as the opposite bank is eroded.

222. (D) Pediplain
A pediplain is an extensive, low-relief plain formed in arid or semi-arid environments. It is created through the process of pedimentation, where steep mountain slopes retreat backward due to erosion. As neighboring pediments expand and coalesce, they eventually form a broad, gently undulating erosional surface. This process is a central part of L.C. King's model of landscape evolution in dry climatic regions.

223. (A) Valley glacier (or Alpine glacier)
A valley glacier, also known as an alpine glacier, is a mass of ice that is confined by the steep walls of a mountain valley. These glaciers originate in high mountain basins or ice fields and flow slowly downhill under the influence of gravity. Their movement is highly constrained by the pre-existing topography, which they significantly modify into U-shaped valleys through intense erosion.

224. (B) The sudden and rapid movement of a coherent mass of rock or debris down a slope.
A landslide is a type of mass wasting characterized by the rapid downward movement of a relatively coherent mass of material. It occurs when the shear stress on a slope exceeds the shear strength of the rock or soil. Factors like heavy rain, earthquakes, or human activities can trigger these events, resulting in the sudden displacement of large volumes of material along a distinct surface.

225. (B) Morphometric analysis
Morphometric analysis is the quantitative study of landforms through the measurement and mathematical analysis of their physical attributes. It involves the systematic calculation of parameters related to the shape, size, and arrangement of features such as drainage basins, slopes, and river networks. This objective approach allows geomorphologists to characterize the landscape precisely and to infer the underlying geological and tectonic processes involved.

226. (A) Ductile and capable of slow flow.
The asthenosphere is a layer of the upper mantle located directly below the lithosphere. While it is composed of solid rock, the high temperatures and pressures allow it to behave in a plastic or ductile manner. This property enables the asthenosphere to flow very slowly over geological time, providing the necessary lubrication and mechanical support for the movement of the overlying tectonic plates.

227. (C) The collapse of a volcano into its own magma chamber after a massive eruption.
A caldera is a large, cauldron-like volcanic depression. It forms when a massive eruption empties a significant portion of the underlying magma chamber. The lack of support causes the summit of the volcano to collapse inward, creating a large, circular hole. Calderas are much larger than simple volcanic craters and can span many kilometers, often becoming the site of large lakes or new volcanic activity.

228. (D) The proposed mechanism was physically implausible.
Despite providing significant evidence for continental drift, Alfred Wegener faced intense criticism because he could not explain how continents moved. He suggested that landmasses plowed through the solid ocean floor, driven by weak tidal and centrifugal forces. Physicists of the

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time easily demonstrated that these forces were far too small to move continents, leading to the widespread rejection of his theory for decades.

229. (C) All Alluvial Fan
An alluvial fan is a fan-shaped deposit of sediment that forms where a high-gradient mountain stream enters a flat, open plain. The sudden decrease in the stream's energy and the loss of its confinement cause it to slow down and drop its sediment load. Over time, the stream shifts back and forth across the plain, building up a gently sloping, triangular mound of debris.

230. (B) An asymmetrical till hill with its steep side facing the ice source.
A drumlin is a streamlined, asymmetrical hill composed of unsorted glacial till. It is a depositional feature shaped by a moving ice sheet. The steep side, known as the stoss end, faces the direction from which the ice advanced, while the gentler, elongated side points in the direction of ice flow. Drumlins provide valuable information about the extent and movement of past continental glaciers.

231. (D) The lifting and removal of loose material by wind.
Deflation is a major process of wind erosion in arid environments. It involves the removal of loose, dry, and fine-grained particles, such as silt and sand, from the ground surface. This selective removal can lower the elevation of the land and lead to the formation of deflation hollows. It often leaves behind a concentrated layer of larger pebbles, known as desert pavement, which protects.

232. (A) Karst environments
Terra rossa is a distinctive, reddish clay-like soil that is frequently found in Karst regions. It is formed as an insoluble residue from the chemical weathering of limestone. As the calcium carbonate in the rock is dissolved and washed away by acidic water, the iron oxides and other minerals remain behind. These minerals accumulate and oxidize, giving the resulting soil its characteristic deep red color.

233. (C) Cave, Arch, Stack, Stump
The erosional evolution of a rocky headland follows a predictable sequence. Waves first exploit weaknesses in the rock to form sea caves. Through continuous erosion, these caves break through to create a sea arch. When the roof of the arch eventually collapses, a tall pillar called a sea stack is left. Finally, further erosion wears the stack down into a low-lying feature known as a stump.

234. (A) Achieved a balance between its transporting capacity and the sediment load it has to carry.
A graded stream is a river system that has reached a state of dynamic equilibrium. It has adjusted its gradient and channel characteristics so that its energy is exactly sufficient to transport the sediment load supplied to it, with neither significant erosion nor deposition occurring. This balanced profile is a fundamental concept in fluvial geomorphology, representing a steady-state condition where the river effectively manages its.

235. (D) Catastrophism
Catastrophism is a historical geological theory that explains the Earth's features as the result of sudden, violent, and widespread events. Proponents believed that major changes, such as the formation of mountains or the extinction of species, occurred during short-lived periods of upheaval. This view was popular before being largely replaced by uniformitarianism, which emphasizes the slow, continuous processes that operate over vast spans of geological time.

236. (B) Divergent plate boundary
The Mid-Atlantic Ridge is the most prominent divergent plate boundary on Earth. It is an underwater mountain range that runs through the center of the Atlantic Ocean, marking the zone where the North American and Eurasian plates, and the South American and African plates, are pulling apart. This process of sea-floor spreading continuously creates new oceanic crust through volcanic activity and shallow-focus earthquakes.

237. (C) Its location on the oceanic side with associated volcanism.
In the classic geosynclinal model, the eugeosyncline is the part of the basin situated further from the stable continent, in deeper marine environments. It is characterized by extremely thick sequences of sediments and,

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most significantly, a large amount of volcanic material like ash and lava flows. This volcanic presence indicates its proximity to active tectonic zones, distinguishing it from the non-volcanic miogeosyncline.

238. (D) The presence of mid-ocean ridges
Alfred Wegener used several lines of evidence to support his theory, including the matching shapes of continents, identical fossils across oceans, and the continuity of ancient mountain belts. He also cited paleoclimatic evidence like glacial deposits. However, the discovery and mapping of mid-ocean ridges occurred much later, during the mid-twentieth century. This evidence was crucial for sea-floor spreading and plate tectonics, rather than Wegener's original theory.

239. (A) Alpine glacier found in a mountain hollow
A cirque glacier is a small alpine glacier that occupies a bowl-shaped depression, or cirque, on the side of a mountain. These glaciers form through the accumulation and compaction of snow in these sheltered hollows. Unlike valley glaciers, they do not descend into lower valleys but remain confined to the high-altitude depressions where they originated, playing a key role in the initial stages of glacial.

240. (A) P-4, Q-2, R-1, S-3
Mass wasting involves various types of downslope movement. Landslides represent rapid displacement of coherent masses. Soil creep is the extremely slow and continuous movement of regolith. Rockfalls occur when fragments drop freely from steep cliffs. Mudflows are characterized by the fast flow of water-saturated soil and debris through channels. Correctly matching these terms reveals the diverse ways gravity reshapes the landscape through different materials.

241. (B) Lahar
A lahar is a specific type of volcanic mudflow or debris flow that occurs on the slopes of a volcano. It is triggered when volcanic ash and rock fragments mix with large volumes of water, often from melting ice, heavy rain, or a breached crater lake. Lahars can travel at very high speeds and are extremely destructive, capable of burying entire towns located in their.

242. (A) Deflections of the plumb line near large mountain masses.
The scientific development of isostasy began during the Great Trigonometrical Survey of India. Researchers noticed that the gravitational pull of the Himalayas caused the plumb lines of their instruments to deflect less than expected. This observation led to the realization that the mountains must be composed of lower-density rock or have deep, buoyant roots, suggesting that the Earth's crust is in a state.

243. (C) Rodinia
While Pangaea is the most famous supercontinent, it was preceded by several others throughout Earth's long history. Rodinia is one such supercontinent that is thought to have existed approximately one billion years ago. It formed through the collision of many smaller landmasses and eventually broke apart, with its fragments later rearranging themselves to form the landmasses that would eventually join together to create Pangaea.

244. (D) Convergent (Oceanic-Continental)
The Andes Mountains are the result of a convergent plate margin where the oceanic Nazca Plate is being subducted beneath the continental South American Plate. As the denser oceanic plate sinks, it causes intense folding of the continental crust and generates magma that feeds the many volcanoes in the range. This process combines both mountain building and explosive volcanic activity along the South American coast.

245. (C) Sea level
In geomorphology, the ultimate base level is the global sea level. This represents the lowest elevation to which a river can erode its bed, as water requires a gradient to flow. A river cannot cut its valley below sea level because the water would lose its energy. While local base levels like lakes can exist, all rivers eventually aim to reach and adjust their.

246. (B) A low-lying, irregular, drowned coastline of glacial origin.
A fiard is a coastal feature common in formerly glaciated, low-relief landscapes like Sweden. It is a drowned glacial valley that is much shallower and broader than a typical fjord. Fiards have irregular, indented coastlines with many small

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islands and peninsulas. They represent the submergence of a low-lying glacial terrain by the sea, rather than the drowning of a deep, steep-walled mountain trough.

247. (D) Saltation
Saltation is a primary method of sediment transport in both aeolian and fluvial environments. It involves sand grains being lifted by the wind or water and then bouncing or skipping along the ground surface. Each time a grain lands, it may kick up other grains, continuing the process. This jumping" motion is the main way sand is moved to form dunes and other depositional landforms.

248. (A) A feature formed by the coalescence of several sinkholes.
A uvala is a complex landform found in Karst topography. It is a large, closed depression that is created when several individual sinkholes, or dolines, grow and eventually merge together. Uvalas are characterized by their irregular, scalloped shape and uneven floors. They represent a more advanced stage of limestone dissolution at the surface compared to the smaller and more symmetrical individual sinkholes from which they.

249. (C) A former shoreline that is now above the current sea level.
A raised beach is a coastal landform that provides clear evidence of a relative fall in sea level. It consists of a former beach and its associated sediments that are now located high above the current reach of the tide. This can be caused either by a global drop in sea level or by the tectonic uplift of the land, as seen during isostatic.

250. (A) 1 and 2 only
Alluvial fans and deltas are both depositional fluvial landforms. Alluvial fans form where mountain streams reach a plain, while deltas form where a river enters a standing body of water. A point bar is also a depositional feature, but it forms on the inner bank of a meander. Therefore, since the third statement incorrectly labels a point bar as an erosional feature, only the first.

251. (D) Morphometric analysis
Morphometric analysis is the quantitative study of the Earth's surface geometry. It involves the mathematical description and analysis of parameters related to a drainage basin and its stream network. By measuring attributes like area, slope, and stream length, scientists can objectively characterize the landscape and draw conclusions about its tectonic, geological, and climatic history. This approach is fundamental to modern geomorphology and hydrology for.

252. (B) Asthenosphere
The asthenosphere is often referred to as the low velocity zone" by seismologists. This is because seismic waves slow down significantly as they enter this part of the upper mantle. The extreme heat and pressure cause the rock to become partially molten or ductile, reducing its rigidity. This property is what allows the tectonic plates of the lithosphere to move slowly over the planet's surface.

253. (C) Island arc at an oceanic-oceanic convergent boundary
The Japanese archipelago is a classic example of a volcanic island arc. It formed at a convergent boundary where two oceanic plates collide. As one plate is subducted beneath the other, it melts, creating magma that rises to form a chain of volcanoes on the overriding plate. This process results in a curved arc of islands characterized by high seismic activity and explosive volcanic eruptions.

254. (D) Stream piracy
Stream piracy, also known as stream capture, is a geomorphic process where a more energetic stream diverts the water of another stream. This usually occurs through head ward erosion, where a river cuts back until it intercepts the channel of a neighboring stream. The captured stream is then forced to flow into the new channel, often leaving its former valley as a wind gap" or dry.

255. (A) An irregular mound of sand and gravel in a retreating glacier.
A kame is a glacial depositional landform consisting of stratified sand and gravel. It forms as a steep-sided mound or hill when meltwater deposits sediment into a depression on the surface of a glacier or in a small lake at the ice edge. When the glacier eventually melts away, the sediment is left behind as an irregular hill on the landscape, providing evidence of.

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256. (B) Wind
A deflation hollow, or blowout, is an erosional landform created by the action of wind. In areas where vegetation is sparse and the ground is dry, the wind can selectively lift and remove loose sand and silt. Over time, this process of deflation scours out a basin-like depression. These features are common in sandy desert environments and can range from small pits to large depressions.

257. (B) The former Yugoslavia (Slovenia, Croatia)
The term Karst" originated from the Kras plateau in the border region between Slovenia and Italy. This area, part of the former Yugoslavia, is internationally famous for its extensive and classic limestone topography. It features many of the defining landforms of the field, including sinkholes, caves, and complex underground drainage systems. Consequently, this region has served as the primary model for scientific studies of.

258. (A) Harder, more resistant rock
A headland is a prominent coastal landform that extends out into the ocean. It remains while the surrounding coastline retreats because it is composed of harder and more resistant rock than the adjacent areas. The energy of the waves is focused on the headland through refraction, yet its geological strength allows it to withstand the erosive forces longer, creating the indented shape of many.

259. (C) Relation between rates of uplift and erosion.
Walther Penck proposed a model of landscape evolution that challenged W.M. Davis's cycle of erosion. Penck emphasized that the shape of a landform is determined by the continuous interaction between the rate of tectonic uplift and the rate of erosion. Unlike Davis, who assumed uplift was rapid and followed by a long period of erosion, Penck argued that both processes occur simultaneously and.

260. (A) Both A and R are true and R is the correct explanation of A.
Paleomagnetism provides compelling physical evidence for the movement of tectonic plates. As new oceanic crust forms at mid-oceanic ridges, it records the Earth's magnetic orientation. The discovery of symmetrical, alternating stripes of magnetic anomalies on both sides of the ridge confirms that the sea floor is spreading outward. This observation fundamentally supports the theory of plate tectonics by proving that crust is continuously.

261. (C) Walther Penck
The concept of slope replacement is a key element of Walther Penck's geomorphic model. He proposed that as a mountain slope erodes, its steepness is not simply reduced over time. Instead, a steep slope can be replaced from below by a gentler slope, such as a pediment. This process of parallel retreat and replacement leads to the development of a low-relief surface, reflecting the ongoing balance between uplift.

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262. (B) Abrasion
Mass wasting refers to the downslope movement of rock, soil, and debris under the direct influence of gravity. Examples include landslides, soil creep, and slumps. Abrasion, however, is a mechanical erosional process. it involves the grinding and scraping of a rock surface by particles carried by a geomorphic agent like wind, water, or ice. Therefore, while related to landscape change, abrasion is not.

263. (D) An eroded dome or basin structure
An annular drainage pattern is characterized by streams that flow in a circular or ring-like path. This pattern typically develops on eroded structural domes or basins where layers of hard and soft rock are exposed at the surface in concentric circles. The streams follow the weaker, more easily eroded layers, resulting in a distinctive circular network that reflects the underlying geological structure of the terrain.

264. (A) A large boulder transported by ice and deposited in an area of different rock type.
A glacial erratic is a large rock or boulder that has been transported a significant distance by a glacier. When the ice melts, the rock is deposited in a new location. Erratics are easily identified because they are often composed of a completely different rock type than the local bedrock. They serve as important indicators of the direction of past ice movement and the.

265. (C) The deposition of a large volume of sediments.
In the classic theory of geosynclines, subsidence is primarily caused by the accumulation of a

massive thickness of sediment. As rivers deposit materials into a shallow marine basin, the sheer weight of these deposits exerts a continuous downward force on the underlying crust. This causes the basin to gradually sink, creating space for even more sediment to accumulate over millions of years of geological.

266. (A) Hydraulic action
A sea cave is primarily formed through the process of hydraulic action. This occurs when the power of ocean waves forces air and water into cracks and joints in the face of a coastal cliff. The sudden increase in pressure as the wave hits, followed by the release as it recedes, weakens the rock and eventually breaks out fragments. Over time, this continuous pounding.

267. (D) Basin area distribution relative to elevation.
The hypsometric curve is a graphical tool used in morphometric analysis to represent the distribution of land area at different elevations within a drainage basin. By plotting the cumulative area against cumulative height, geomorphologists can characterize the overall shape of the basin. This curve is valuable for identifying the stage of a landscape's erosional maturity and for comparing the geomorphic evolution of different.

268. (B) Deep-focus earthquakes
Divergent plate boundaries, such as mid-oceanic ridges and rift valleys, are characterized by shallow-focus earthquakes. This is because the lithosphere is thin and hot at these margins, and the crustal fracturing occurs relatively near the surface. Deep-focus earthquakes, on the other hand, are exclusively associated with subduction zones at convergent boundaries, where a cold plate is forced deep into the Earth's mantle before rupturing.

269. (C) Continental margin
The continental margin is the underwater zone that separates the dry land of a continent from the deep ocean floor. It consists of three main parts: the shallow, gently sloping continental shelf; the steeper continental slope; and the more gradual continental rise, which is formed by the accumulation of sediment at the base of the slope. These features mark the transition between continental and.

270. (A) 2, 4, 3, 1
The geological time scale is divided into several units of varying duration. An eon is the largest unit, encompassing billions of years. Eons are divided into eras, which are further subdivided into periods. Finally, periods are broken down into epochs, which are the smallest of these major units. This hierarchical system allows scientists to organize and categorize the vast span of Earth's history into.

271. (A) Seif or longitudinal dune
In some desert environments, the shape of a sand dune can change over time. If a barchan dune is subjected to a shift in wind conditions or a change in sand supply, its horns may become greatly elongated. If the central crescent part is then removed or breached, the dune can transform into a seif, which is a type of long, linear ridge or.

272. (B) Maintained its course while downcutting through underlying structures.
A superimposed drainage pattern develops when a river is established on a younger rock layer that overlies a complex, older geological structure. As the river cuts downward, it eventually reaches the older rocks. Because it already has a set course, it continues to erode vertically into the underlying structure, regardless of the hardness or orientation of the rocks. This results in a river path.

273. (B) Tectonic activity, including earthquakes and volcanism, due to a nearby plate boundary.
A Pacific-type, or active, continental margin is located at or near a tectonic plate boundary. These margins are characterized by high levels of geological activity, including frequent earthquakes, volcanic eruptions, and the presence of deep-sea trenches or high mountain ranges. This is in sharp contrast to passive margins, which are situated far from plate boundaries and are relatively stable, experiencing very little tectonic movement.

274. (A) Less dense rock
Pratt's model of isostasy explains the varying heights of the Earth's crust by assuming differences in density. According to this model, all crustal blocks sink to a uniform depth of compensation. Therefore, higher features like mountain ranges must be composed of rock

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that is significantly less dense than the material forming lower features like plains or the ocean floor, allowing them to sit.

275. (C) Peneplain
According to the Davisian cycle of erosion, the ultimate end product of the landscape's evolution is a peneplain. This is a vast, low-lying, and nearly flat plain that represents a landscape that has been almost entirely worn down to its base level by millions of years of continuous weathering and fluvial erosion. It is the final stage before a new cycle might begin through.

276. (D) Valley glaciers coalesce on the plains below.
A piedmont glacier is a large, lobe-shaped mass of ice that forms at the base of a mountain range. It is created when one or more valley glaciers flow out of their steep mountain canyons and onto a relatively flat plain. No longer confined by valley walls, the ice spreads out laterally into a wide, fan-like shape, often covering a significant area of the.

277. (C) Island mountain
The term inselberg" is a German word that literally translates to island mountain." This name accurately describes the physical appearance of these features, which are isolated, steep-sided hills of resistant rock that rise abruptly from a surrounding flat plain. They appear like rocky islands in a sea of low-relief terrain, representing remnants of an older landscape that have survived extensive periods of geomorphic leveling.

278. (B) The Hawaiian-Emperor seamount chain
The Hawaiian-Emperor seamount chain is a classic example of a hotspot track. It consists of a long line of volcanic islands and underwater mountains that were formed as the Pacific Plate moved over a stationary mantle plume. The age of the volcanoes increases as you move away from the current hotspot under the Big Island of Hawaii, providing clear evidence of the direction and.

279. (D) Seismic wave behavior
Because humans cannot directly observe the deep interior of the Earth, scientists must rely on indirect methods to study its structure. The most important tool is the analysis of seismic waves produced by earthquakes. By studying how P-waves and S-waves change speed and direction as they pass through the planet, researchers have been able to identify the distinct layers, including the crust, mantle, and.

280. (C) P-3, Q-2, R-1, S-4
Landforms are the result of specific geomorphic processes. Alluvial fans are created by fluvial deposition. Eskers form through fluvio-glacial deposition in subglacial tunnels. Yardangs are sculpted by the abrasive action of wind-driven sand. Sea stacks are isolated rock pillars created by marine erosion along coastlines. Correctly matching these features with their processes demonstrates an understanding of the diverse natural agents that shape the Earth's surface.

281. (C) Deflation
Rivers accomplish their erosional work through several mechanical and chemical processes, including hydraulic action, abrasion, and attrition. These involve the power of moving water and the impact of sediment. Deflation, however, is not a fluvial process. it is an aeolian process where the wind lifts and removes loose, fine-grained material from the surface. Therefore, deflation is associated with wind erosion rather than river.

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282. (A) Not located at a plate boundary and is relatively stable.
An Atlantic-type, or passive, continental margin is located within the interior of a tectonic plate, far from any active plate boundary. These margins are geologically stable and are characterized by wide continental shelves and thick accumulations of sediment. Unlike active margins, they experience very few earthquakes and no volcanic activity, reflecting the lack of intense tectonic forces acting upon the coastline in these.

283. (D) Gorge
Landforms are classified as either erosional or depositional. Alluvial fans, moraines, and deltas are all created by the accumulation of materials like sediment or glacial debris. A gorge, however, is an erosional landform. it is a deep, narrow, and steep-sided valley that is formed by the rapid downward cutting of a river into its bed, often during its youthful stage of development.

284. (B) Crevasse
A crevasse is a deep, narrow crack or fissure that develops in the upper part of a glacier. This layer of ice is brittle and cannot easily deform to accommodate the glacier's movement over uneven terrain. As the glacier flows over a steep slope or around a bend, the resulting tension causes the ice to fracture, creating these hazardous openings that can be several.

285. (C) Pumping of groundwater from a well
A cone of depression is a hydrologic feature that forms in the water table around a pumping well. As water is withdrawn from the aquifer faster than it can be replaced by the surrounding groundwater, the water table drops in a circular area around the well. This results in a funnel-shaped depression, which can affect the yield of neighboring wells and the overall flow.

286. (D) Tombolo
Coastal landforms are created by both erosional and depositional processes. Sea cliffs, wave-cut platforms, and sea arches are all products of the destructive power of waves. A tombolo, however, is a depositional feature. It is a ridge of sand or gravel that forms as waves and currents deposit sediment, eventually creating a land bridge that connects an offshore island to the mainland.

287. (A) The degree to which the basin shape approaches a circle.
In morphometric analysis, the circularity ratio is a quantitative measure of a drainage basin's shape. It is calculated by comparing the area of the basin to the area of a circle with the same perimeter. This ratio provides insights into the hydrological behavior of the basin, as more circular basins tend to have a more concentrated flood response compared to elongated or irregular.

288. (B) Surface waves (Love and Rayleigh)
While body waves like P-waves and S-waves travel through the Earth's interior, surface waves are confined to the upper layers of the crust. These waves, including Love and Rayleigh waves, have higher amplitudes and longer durations than body waves. Consequently, they cause the most intense ground shaking and are responsible for the vast majority of destruction to buildings and infrastructure during a significant.

289. (B) Isostasy
The concept of the level of compensation" is a fundamental part of the Pratt model of isostasy. It posits that there is a specific depth within the Earth at which all the overlying crustal blocks, regardless of their height or density, exert the same amount of pressure. Above this depth, the Earth's features are in gravitational balance, floating in a state of mechanical equilibrium.

290. (A) 1 and 2 only
Scientific knowledge of the Earth's interior confirms that the crust is the outermost and thinnest layer. Below it lies the mantle, which is the largest layer by volume. However, the core is not composed of silicates; instead, it consists primarily of metallic iron and nickel. Therefore, while the first two statements provided are correct, the third is factually incorrect regarding the core's composition.

291. (C) Gravity acting on a steep, unstable slope
While factors like heavy rain or human activities can trigger a landslide, the primary and essential driving force is gravity. Gravity acts on every mass of rock and soil on a slope. When the downward force exceeds the internal strength of the material or the friction holding it in place, a landslide occurs. This rapid mass wasting event is a direct consequence of gravitational.

292. (D) A basin or structural depression.
A centripetal drainage pattern is characterized by streams and rivers that flow from all directions toward a central low-lying area. This pattern typically develops in closed basins or structural depressions where there is no outward exit for the water. The streams converge in the center, often feeding into a central lake or a salt pan in arid regions, reflecting the inward slope.

293. (C) From the gentle side to the steep side.
A roche moutonnée is a classic landform that indicates the direction of past glacial flow. The glacier moves over a resistant rock mass, abrading and smoothing the side it first encounters, which results in a gentle, polished slope. As the ice moves over the crest, it pulls away or plucks" fragments from the downstream side, creating a steep, jagged profile. This identifies the flow.

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294. (B) Deflation
A desert pavement is a surface of coarse pebbles and gravel found in arid environments. It is created through the process of deflation, where the wind selectively removes the finer particles of sand and silt from the surface. Over time, the larger stones that the wind cannot carry are left behind, eventually forming a concentrated, interlocking layer that protects the underlying material from further wind.

295. (D) Regressive (Isostatic)
Plate tectonic theory recognizes three main types of boundaries: divergent (constructive), convergent (destructive), and transform (conservative). These terms describe the relative motion and crustal impact at the plate margins. Regressive" or isostatic" is not a type of plate boundary; rather, isostasy refers to the vertical gravitational equilibrium of the crust, making it the correct term that does not fit the tectonic classification.

296. (A) The drowning of a river valley by a rise in sea level.
A ria is a type of coastal inlet that forms when a relative rise in sea level floods a pre-existing river valley. Rias are characterized by their dendritic or branching shape, which reflects the former drainage pattern of the land. Unlike fjords, which are flooded glacial valleys, rias are the result of the sea submerging a typical fluvial landscape on a non-glaciated or.

297. (C) A time span during which a steady state or equilibrium is achieved in a landscape.
In geomorphology, the concept of graded time" refers to a specific time scale where a landscape or a part of it, like a river, achieves a state of dynamic equilibrium. During this period, the geomorphic processes are balanced, and the landforms remain relatively stable despite ongoing energy and material flow. This is one of the three time scales proposed by Schumm and.

298. (A) The observed effects and damage at a particular place.
The Mercalli scale is a qualitative measure used to rank the intensity of an earthquake. Unlike magnitude scales that measure the energy released at the source, the Mercalli scale is based on human observations and the amount of physical damage to structures at a specific location. It uses Roman numerals to describe effects ranging from not felt" to extreme destruction" across the affected region.

299. (D) Tethys Sea
In Alfred Wegener's theory of continental drift, the supercontinent Pangaea initially split into two smaller landmasses: Laurasia in the north and Gondwanaland in the south. These two massive continents were separated by a large, shallow, and elongated marine waterway known as the Tethys Sea. This sea played a significant role in the geological history of the Earth, eventually being closed by tectonic plates.

300. (B) Plucking
Plucking is an important erosional process carried out by glaciers. As the ice moves over the bedrock, meltwater penetrates into fractures and then freezes, causing the rock to crack and loosen. The moving glacier then physically lifts and incorporates these large blocks of rock into its mass, transporting them away. This process is responsible for creating the jagged and irregular surfaces often seen.

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CHAPTER 02
Structural Geology

1. Which of the following terms defines the force per unit area acting on a rock?
(A) Strain
(B) Stress
(C) Deformation
(D) Ductility

2. The change in shape or size of a rock body in response to applied force is known as:
(A) Strain
(B) Stress
(C) Fracture
(D) Pressure

3. Identify the correct statement regarding the factors controlling rock deformation.
(A) High temperatures typically act to decrease a rock's ductility.
(B) Rapid strain rates tend to promote ductile deformation over brittle.
(C) High confining pressure reduces fracturing and increases ductility.
(D) The presence of pore fluids has no significant effect on behavior.

4. A rock is subjected to compressional stress. If it deforms by shortening and thickening, this type of strain is best described as:
(A) Elastic strain
(B) Brittle strain
(C) Tensional strain
(D) Ductile strain

5. Match the items in List I with those in List II.
List I: (Type of Deformation)
P. Elastic Deformation
Q. Plastic Deformation
R. Brittle Deformation
S. Viscous Deformation
List II: (Description)
1. Permanent change in shape by flowing
2. Fracturing or breaking of the rock
3. Temporary change in shape, recoverable
4. Permanent change in shape without fracture
Codes:
(A) P-3, Q-4, R-2, S-1
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-1, R-4, S-2
(D) P-4, Q-3, R-2, S-1

6. Consider the following statements and select the correct option.
Statement I : Stress is a cause, while strain is the effect.
Statement II : All rocks exhibit the same mechanical behavior under identical stress conditions.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct, but Statement II is incorrect.
(D) Statement I is incorrect, but Statement II is correct.

7. Which of the following statements about principal stresses is incorrect?
(A) The three principal stresses ($\sigma 1$, $\sigma 2$, $\sigma 3$) are mutually perpendicular.
(B) Shear stresses are zero on the planes acted upon by principal stresses.
(C) The state of stress at a point can be represented by a stress ellipsoid.
(D) $\sigma 1$ always represents the minimum compressive stress.

8. All of the following are factors that promote brittle behavior in rocks EXCEPT:
(A) High confining pressure
(B) High strain rate
(C) Low temperature
(D) Low fluid pressure

9. Why does increasing confining pressure tend to inhibit rock failure by fracturing?
(A) It decreases the overall stress on the rock.
(B) It increases the temperature of the rock.

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(C) It acts to close any microcracks that might form.
(D) It changes the mineral composition of the rock.

10. The following question consists of two statements — Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A) : In a Mohr circle diagram for a state of stress, the center of the circle lies on the normal stress axis.
Reason (R) : The Mohr circle is a graphical representation where shear stresses are plotted against normal stresses, and principal stress planes have zero shear stress.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

11. A geologist observes a set of sedimentary layers that are tilted at 30 degrees, which are overlain by a set of horizontal sedimentary layers. A basal conglomerate is present at the contact. What type of structure is this?
(A) A disconformity
(B) A nonconformity
(C) A paraconformity
(D) An angular unconformity

12. In the context of strain analysis, what is the most appropriate description of a strain ellipsoid?
(A) A geometric representation of the state of stress at a point.
(B) A sphere deformed into an ellipsoid as a rock undergoes strain.
(C) A specific tool used to calculate fault orientation in the field.
(D) A measure of a rock's resistance to deformation and failure.

13. Identify the correct pair related to the symmetry of deformation.
(A) Monoclinic symmetry - Three mutually perpendicular planes of symmetry
(B) Orthorhombic symmetry - One plane of symmetry
(C) Triclinic symmetry - No planes or axes of symmetry
(D) Axial symmetry - Two non-perpendicular planes of symmetry

14. What term describes the continuous, non-recoverable deformation that occurs over a period of time?
(A) Instantaneous rupture
(B) Elastic rebound
(C) Brittle failure
(D) Progressive deformation

15. Consider the following statements about unconformities:
1. A nonconformity separates younger sedimentary rocks from older metamorphic or igneous rocks.
2. A disconformity is a surface of erosion or non-deposition between parallel sedimentary layers.
3. A paraconformity is easily identified by the angular discordance between the layers.
Which of the above statement(s) is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

16. What is the definition of a fold's axial plane?
(A) The line connecting points of maximum curvature on a folded surface.
(B) The surface that connects the hinge lines of successive folded layers.
(C) The sides of a fold between the crest and the trough.
(D) The angle between a horizontal plane and the fold's hinge line.

17. Which of the following is an incorrect statement regarding fold geometry?
(A) The limbs of a fold are the regions on either side of the hinge.
(B) The hinge line is the line of minimum curvature on a fold surface.
(C) An anticline is a fold that is typically convex upward.
(D) A syncline is a fold that is typically concave upward.

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18. If the axial plane of a fold is inclined and both limbs dip in the same direction, with one limb being overturned, the fold is classified as:
(A) An overturned fold
(B) An upright fold
(C) A recumbent fold
(D) An isoclinal fold

19. Consider the following statements and select the correct option.
Statement I : In a non-plunging anticline, the oldest rocks are exposed in the core.
Statement II : In a non-plunging syncline, the youngest rocks are exposed in the core.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct, but Statement II is incorrect.
(D) Statement I is incorrect, but Statement II is correct.

20. Arrange the following types of folds in chronological order of increasing deformation, assuming a single progressive deformational event.
1. Gentle fold
2. Isoclinal fold
3. Open fold
4. Tight fold

Select the correct answer using the codes given below:
(A) 1, 3, 4, 2
(B) 2, 4, 3, 1
(C) 1, 2, 3, 4
(D) 3, 1, 4, 2

21. What is the term for a fold that has a horizontal axial plane?
(A) Upright fold
(B) Inclined fold
(C) Recumbent fold
(D) Overturned fold

22. The V-rule" for outcrop patterns states that when a dipping bed crosses a valley, the outcrop pattern V's" in which direction?
(A) Opposite to the direction of dip
(B) In the direction of dip
(C) In the direction of strike
(D) Parallel to the valley axis

23. Which of the following is a primary criterion for the recognition of folds in the field?
(A) The presence of a fault scarp
(B) The occurrence of a basal conglomerate
(C) The presence of columnar joints
(D) Changes in the dip and strike of rock layers

24. A dome structure, when eroded, will expose rocks of what relative age at its center?
(A) Oldest
(B) Youngest
(C) Intermediate
(D) Mixed ages due to faulting

25. The following question consists of two statements — Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A) : Superimposed folding can create complex interference patterns such as domes and basins.
Reason (R) : Successive deformation events with different stress orientations can refold existing fold structures.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

26. A fold in which the limbs are parallel to each other is known as:
(A) A chevron fold
(B) An isoclinal fold
(C) An open fold
(D) A box fold

27. The line formed by the intersection of the axial plane and the surface of the earth is the:
(A) Axial trace
(B) Hinge line
(C) Fold axis
(D) Limb

28. Which of the following is NOT a recognized type of fold classification?
(A) Classification based on inter-limb angle
(B) Classification based on the attitude of the

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axial plane
(C) Classification based on symmetry
(D) Classification based on the rock's mineral composition

29. On a Mohr circle diagram, the point where the circle intersects the failure envelope indicates:
(A) The onset of elastic deformation
(B) The state of hydrostatic pressure
(C) The stress conditions required for fracture or faulting
(D) The point of maximum principal stress

30. Match the items in List I with those in List II.
List I: (Fold Type)
P. Plunging Fold
Q. Chevron Fold
R. Symmetrical Fold
S. Asymmetrical Fold
List II: (Geometric Feature)
1. Limbs have unequal length and dip at different angles
2. Axial plane is essentially vertical and bisects the fold
3. Hinge line is inclined to the horizontal
4. Straight limbs and a sharp, angular hinge
Codes:
(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-4, R-2, S-1
(C) P-4, Q-3, R-1, S-2
(D) P-3, Q-2, R-4, S-1

31. In the context of a fault, what does the term 'hanging wall' refer to?
(A) The rock block that lies above the fault plane.
(B) The rock block that lies below the fault plane.
(C) The exposed surface of the fault plane.
(D) A block that has not moved during faulting.

32. Which statement correctly distinguishes between a normal fault and a reverse fault?
(A) In a normal fault, the hanging wall moves up relative to the footwall; in a reverse fault, it moves down.
(B) In a normal fault, the hanging wall moves down relative to the footwall; in a reverse fault, it moves up.
(C) Normal faults are caused by compression, while reverse faults are caused by tension.
(D) Normal faults are always steep, while reverse faults are always low-angle.

33. The total displacement vector along a fault plane is known as the:
(A) Heave
(B) Throw
(C) Net slip
(D) Separation

34. A geologist is examining a road cut and observes that a distinctive sandstone layer is present at one end, disappears for 50 meters, and then reappears at the other end. The layers above and below are continuous. This omission of strata is characteristic of a:
(A) Thrust fault
(B) Syncline
(C) Unconformity
(D) Normal fault

35. The horizontal component of displacement in a dip-slip fault is termed:
(A) Throw
(B) Heave
(C) Strike-slip
(D) Net slip

36. A low-angle reverse fault, with a dip of less than 45 degrees, is specifically called a:
(A) Normal fault
(B) Thrust fault
(C) Strike-slip fault
(D) Transform fault

37. Consider the following statements and select the correct option.
Statement I : Slickensides are polished and striated surfaces on a fault plane that indicate the direction of movement.
Statement II : Fault breccia is a zone of angular rock fragments created by the grinding action along a fault.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct, but Statement II is incorrect.
(D) Statement I is incorrect, but Statement II is correct.

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38. Which type of fault is primarily characterized by horizontal motion, with blocks sliding past one another?
(A) Strike-slip fault
(B) Dip-slip fault
(C) Normal fault
(D) Reverse fault

39. The apparent displacement of a bed, as seen in a vertical cross-section, is known as:
(A) Net slip
(B) Strike slip
(C) Separation
(D) Heave

40. Consider the following statements regarding the causes of faulting:
1. Normal faults are typically caused by tensional stresses that pull the crust apart.
2. Reverse and thrust faults are generally the result of compressional stresses that shorten the crust.
3. Strike-slip faults are produced by shear stresses.

Which of the above statement(s) is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

41. A strike-slip fault where the block opposite you has moved to the right is called a:
(A) Sinistral fault
(B) Oblique-slip fault
(C) Left-lateral fault
(D) Dextral fault

42. What is the fundamental difference between a fracture and a joint?
(A) A fracture involves shear motion, while a joint does not.
(B) A joint is a type of fracture across which there has been no appreciable movement.
(C) Joints are always smaller than fractures.
(D) Fractures only occur in metamorphic rocks, while joints occur in all rock types.

43. A planar fabric in a rock, resulting from the parallel alignment of platy or elongate minerals, is best described as:
(A) Lineation
(B) Jointing
(C) Foliation
(D) Bedding

44. Which of the following is NOT a type of lineation?
(A) Intersection lineation
(B) Mineral lineation
(C) Crenulation lineation
(D) Axial plane lineation

45. The closely spaced, parallel fractures that impart a fissility to low-grade metamorphic rocks like slate are known as:
(A) Slaty cleavage
(B) Schistosity
(C) Gneissic banding
(D) Columnar joints

46. What is the primary origin of joints in rocks?
(A) Shear stress occurring during large-scale faulting events.
(B) Tensional stress from cooling, unloading, or tectonic uplift.
(C) High-grade metamorphism leading to chemical recrystallization.
(D) Chemical weathering occurring along pre-existing bedding planes.

47. The term for a fabric dominated by linear elements, indicating a direction of tectonic transport or stretching, is:
(A) S-tectonite
(B) LS-tectonite
(C) Non-tectonite
(D) L-tectonite

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48. What is the general relationship between rock cleavage and the axial plane of folds?
(A) Cleavage typically forms parallel or sub-parallel to the axial plane.
(B) Cleavage typically forms perpendicular to the axial plane.
(C) Cleavage is unrelated to the orientation of folds.
(D) Cleavage only forms on the limbs of folds, not in the hinge.

49. A foliation in a medium-to-high-grade metamorphic rock, defined by the parallel

alignment of visible platy minerals like micas, is called:
(A) Slaty cleavage
(B) Fracture cleavage
(C) Schistosity
(D) Crenulation

50. The process by which a magma body makes space for itself by breaking off and sinking blocks of the surrounding country rock is known as:
(A) Diapirism
(B) Stoping
(C) Forceful injection
(D) Cauldron subsidence

51. Which of the following best describes the mechanical principle of folding by buckling?
(A) Passive bending of layers due to vertical forces.
(B) Layer-parallel compression causing instability and wave-like forms.
(C) Slippage between layers, like a deck of cards being bent.
(D) Gravitational collapse of an uplifted area.

52. In Anderson's theory of faulting, what type of fault would you expect to form in a compressional tectonic regime where σ1 is horizontal and σ3 is vertical?
(A) Normal fault
(B) Reverse fault
(C) Strike-slip fault where σ2 is vertical
(D) Oblique-slip fault

53. Ring dykes and cone sheets are intrusive features typically associated with:
(A) Large batholiths emplaced primarily by the process of diapirism.
(B) Caldera formation and the collapse or resurgence of a central block.
(C) Tensional stresses within the crust of a developing rift valley.
(D) Shear zones directly related to movement along transform faults.

54. The forceful intrusion of magma, which actively pushes aside and deforms the surrounding country rock, is a mechanism of pluton emplacement called:
(A) Stoping
(B) Zone melting
(C) Diapirism
(D) Assimilation

55. The following question consists of two statements — Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A) : The orientation of principal stresses determines the type of fault that forms.
Reason (R) : Normal faults form when the maximum principal stress (σ1) is vertical, allowing for crustal extension.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

56. What is the defining characteristic of a cone sheet?
(A) Vertical, ring-shaped intrusions in the crust.
(B) Dykes dipping inwards towards a common center or focus.
(C) Saucer-shaped sills found in layered sequences.
(D) Dykes dipping outwards from a common central focus.

57. An unconformity where parallel sedimentary layers are separated by a surface of erosion or non-deposition is a:
(A) Nonconformity
(B) Angular unconformity
(C) Disconformity
(D) Buttress unconformity

58. Identify the incorrect statement about Mohr's circle.
(A) It represents the state of stress at a point in two dimensions.
(B) The radius of the circle is equal to the value (σ1 - σ3)/2.
(C) The maximum shear stress is represented by the circle's radius.
(D) The horizontal axis represents strain and the vertical is stress.

59. The angle between the axial plane of a fold and a vertical plane is known as the:
(A) Plunge of the fold

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(B) Dip of the axial plane
(C) Inclination of the fold
(D) Rake of the fold

60. Match the items in List I with those in List II.
List I: (Structural Feature)
P. Normal Fault
Q. Reverse Fault
R. Strike-Slip Fault
S. Upright Folds
List II: (Dominant Stress Regime)
1. Horizontal Compression
2. Shear
3. Tension
4. Horizontal Compression
Codes:
(A) P-3, Q-1, R-2, S-4
(B) P-1, Q-3, R-2, S-4
(C) P-3, Q-4, R-1, S-2
(D) P-2, Q-1, R-3, S-4

61. Which of these is a key line of evidence for recognizing a fault in the field?
(A) Gradual change in grain size
(B) Presence of fossils
(C) Truncation of bedding or other geological structures
(D) Symmetrical repetition of strata

62. In a strike-slip fault regime according to Anderson's theory, which principal stress is typically oriented vertically?
(A) $\sigma 1$ (maximum)
(B) $\sigma 2$ (intermediate)
(C) $\sigma 3$ (minimum)
(D) All three are horizontal

63. The mechanism of folding that involves slip between adjacent layers, analogous to bending a phone book, is called:
(A) Flexural slip
(B) Buckling
(C) Bending
(D) Passive flow

64. A lineation formed by the alignment of elongate minerals like hornblende is a:
(A) Crenulation lineation
(B) Intersection lineation
(C) Mineral lineation
(D) Slickenside lineation

65. A tectonic fabric that shows both a well-developed foliation (planar fabric) and a well-developed lineation (linear fabric) is termed:
(A) S-tectonite
(B) L-tectonite
(C) LS-tectonite
(D) B-tectonite

66. What is the most likely cause of cauldron subsidence, which leads to the formation of ring dykes?
(A) A sudden, large-scale increase in internal magmatic pressure.
(B) Withdrawal of magma from a chamber causing the roof to collapse.
(C) Regional tensional stress that causes the splitting of the crust.
(D) Regional compressional stress squeezing a magma chamber at depth.

67. Consider the following statements and select the correct option.
Statement I : Progressive deformation refers to a single, continuous deformation al event.
Statement II : Superimposed deformation involves multiple, separate deformational events.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct, but Statement II is incorrect.
(D) Statement I is incorrect, but Statement II is correct.

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68. Which of the following is not a primary factor influencing whether a rock behaves in a brittle or ductile manner?
(A) Rock color
(B) Temperature
(C) Strain rate
(D) Confining pressure

69. A fold with an inter-limb angle between 70° and 120° is classified as:
(A) Gentle
(B) Open
(C) Tight
(D) Isoclinal

70. Consider the following statements about fault-related terminology:
1. 'Slip' refers to the actual displacement between two points that were adjacent before faulting.
2. 'Separation' is the apparent offset of a geological marker and may not represent the true displacement.
3. 'Throw' is the horizontal component of dip-slip.

Which of the above statement(s) is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

71. An unconformity that is extremely difficult to recognize because the strata above and below are parallel and there is no visible erosion surface is a:
(A) Disconformity
(B) Paraconformity
(C) Nonconformity
(D) Angular unconformity

72. What is the primary difference between schistosity and slaty cleavage?
(A) Slaty cleavage is found in igneous rocks, while schistosity is in metamorphic rocks.
(B) Schistosity is defined by mineral grains large enough to be seen with the naked eye, while slaty cleavage is not.
(C) Schistosity forms perpendicular to the axial plane of folds, while slaty cleavage is parallel.
(D) There is no fundamental difference; the terms are interchangeable.

73. The outcrop pattern of a non-plunging, upright syncline will show:
(A) A random pattern of rock ages.
(B) The oldest rocks in the core, with progressively younger rocks away from the center.
(C) The youngest rocks in the core, with progressively older rocks away from the center.
(D) Repetition of strata due to faulting.

74. A large-scale strike-slip fault that forms the boundary between two tectonic plates is known as a:
(A) Thrust fault
(B) Normal fault
(C) Transform fault
(D) Growth fault

75. What is the best description of a monocline?
(A) A specific type of fold structure with only a single limb.
(B) A fault type that appears similar to a folded rock structure.
(C) A step-like fold with a steeper zone in horizontal layers.
(D) A fold structure characterized by having two distinct axial planes.

76. The concept of symmetry in deformation helps to:
(A) Determine the absolute age of the rock.
(B) Infer the kinematics and orientation of the strain field.
(C) Identify the mineral composition of the rock.
(D) Calculate the confining pressure during deformation.

77. Which of the following structures is NOT a result of brittle deformation?
(A) Fault
(B) Joint
(C) Fold
(D) Fracture

78. A geologist maps a series of concentric, elliptical outcrop patterns. The rocks in the center are the oldest. This structure is a(n):
(A) Eroded dome
(B) Eroded basin
(C) Plunging syncline
(D) Plunging anticline

79. The vertical component of net slip on a fault is called:
(A) Heave
(B) Rake
(C) Throw
(D) Pitch

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80. The following question consists of two statements — Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A) : Repetition of strata is a common feature observed when drilling through a sequence affected by a thrust fault.
Reason (R) : Thrust faults place older rocks on top of younger rocks, causing a drill to encounter the same stratigraphic section more than once.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

81. A lineation formed by the intersection of bedding and cleavage is an example of:
(A) A mineral lineation
(B) A crenulation cleavage
(C) A boudinage structure
(D) An intersection lineation

82. What is the most appropriate name for a fold with a rounded hinge and straight limbs?
(A) Concentric fold
(B) Chevron fold
(C) Box fold
(D) Ptygmatic fold

83. Identify the incorrect pair.
(A) Normal Fault - Tensional stress
(B) Reverse Fault - Compressional stress
(C) Thrust Fault - Tensional stress
(D) Strike-slip Fault - Shear stress

84. The process of rock failure under constant stress over a long period of time is known as:
(A) Elastic rebound
(B) Seismic slip
(C) Brittle fracture
(D) Creep

85. A geologist logs the following sequence of events in a region. Place them in the correct chronological order from oldest to youngest.
1. Deposition of a horizontal sandstone layer.
2. Tilting and erosion of the sandstone and underlying layers.
3. Intrusion of a granite pluton into a schist basement.
4. Deposition of a horizontal conglomerate and shale layer on the eroded, tilted surface.

Select the correct answer using the codes given below:
(A) 3, 1, 2, 4
(B) 1, 2, 3, 4
(C) 3, 2, 1, 4
(D) 2, 4, 3, 1

86. Which factor tends to decrease the ductility of a rock?
(A) Increase in temperature
(B) Increase in strain rate
(C) Increase in confining pressure
(D) Presence of pore fluids

87. In two-dimensional stress analysis, the normal and shear stress on any plane can be determined if:
(A) Only the maximum principal stress is known.
(B) Only the minimum principal stress is known.
(C) The magnitudes and orientations of the two principal stresses are known.
(D) The rock's density is known.

88. If two fold systems are superimposed, resulting in a 'Type 1' interference pattern (dome-and-basin), what is the likely initial orientation of the two fold sets?
(A) Both were recumbent and parallel.
(B) One was upright and one was recumbent.
(C) Both were plunging in the same direction.
(D) Both were upright and they interfered at a high angle.

89. A fault in which the movement is a combination of both dip-slip and strike-slip is called a(n):
(A) Transform fault
(B) Listric fault
(C) Oblique-slip fault
(D) Detachment fault

90. Match the items in List I with those in List II.
List I: (Structure)
P. Lineation
Q. Foliation
R. Joint
S. Fault

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List II: (Description)
1. A planar fabric in a rock
2. A fracture with measurable displacement
3. A linear fabric in a rock
4. A fracture with no measurable displacement

Codes:
(A) P-1, Q-3, R-2, S-4
(B) P-3, Q-1, R-4, S-2
(C) P-4, Q-2, R-1, S-3
(D) P-3, Q-1, R-2, S-4

91. The V" of an outcrop of a dipping bed points downstream. What is the relationship between the dip of the bed and the valley gradient?
(A) The bed is dipping more steeply than the valley gradient, in the same direction.
(B) The bed is horizontal.
(C) The bed is dipping upstream.
(D) The bed is dipping less steeply than the valley gradient, in the same direction.

92. Which of the following is the best definition of a competent" layer in the context of folding?
(A) A layer that deforms easily by flowing.
(B) A strong, stiff layer that tends to buckle and control the fold wavelength.
(C) A weak layer that accommodates most of the strain.
(D) A layer that fractures easily under stress.

93. The term 'cleavage' in structural geology refers to:
(A) A mineral's tendency to break along planes of weakness.
(B) A primary layering in a sedimentary rock.
(C) A set of closely spaced, parallel planar surfaces induced by deformation.
(D) The separation of a rock into layers during weathering.

94. What is a primary cause for the formation of ring dykes?
(A) Magmatic intrusion along a circular fracture from regional extension.
(B) Updoming of the surface by magma causing radial fractures to form.
(C) Lateral injection of magma into the crust from a distant source.
(D) Collapse of a central block along a fracture with magma filling it.

95. Consider the following statements and select the correct option.
Statement I : A rock's behavior can change from ductile to brittle if the strain rate is increased.
Statement II : A rock's behavior can change from brittle to ductile if the temperature is increased.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct, but Statement II is incorrect.
(D) Statement I is incorrect, but Statement II is correct.

96. A fold where the limbs dip away from the axial plane, and the oldest rocks are in the core is a(n):
(A) Syncline
(B) Anticline
(C) Monocline
(D) Homocline

97. The surface separating the hanging wall and the footwall of a fault is the:
(A) Fault scarp
(B) Fault trace
(C) Fault plane
(D) Slickenside

98. All of the following are typically associated with fault zones EXCEPT:
(A) Basal conglomerate
(B) Mylonite
(C) Gouge
(D) Breccia

99. The mechanical process of pluton emplacement involving the buoyant rise of a low-density magma body through denser surrounding rock is called:
(A) Stoping
(B) Cauldron subsidence
(C) Diapirism
(D) Forceful injection

100. Consider the following statements about rock cleavage:
1. Slaty cleavage is typical of low-grade metamorphic conditions.
2. Schistosity involves the alignment of fine-

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grained minerals not visible to the naked eye.
3. Cleavage often forms perpendicular to the direction of maximum shortening.

Which of the above statement(s) is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

101. An orthorhombic symmetry in a deformed rock implies:
(A) Deformation was purely non-coaxial (simple shear).
(B) Deformation was purely coaxial (pure shear).
(C) There are no planes of symmetry.
(D) The strain ellipsoid is a sphere.

102. In a three-dimensional stress state, what is the relationship between the principal stresses?
(A) $\sigma 1 > \sigma 2 > \sigma 3$
(B) $\sigma 1 = \sigma 2 = \sigma 3$
(C) $\sigma 1 < \sigma 2 < \sigma 3$
(D) $\sigma 1$ and $\sigma 3$ are compressive, $\sigma 2$ is tensional

103. Which is the most definitive criterion for recognizing an unconformity?
(A) A change in rock color.
(B) A significant gap in the fossil record across a contact.
(C) The presence of a thin shale layer.
(D) A change in the dip of the beds.

104. A fold that has a sharp, angular hinge and straight limbs is known as a:
(A) Concentric fold
(B) Box fold
(C) Recumbent fold
(D) Chevron fold

105. The effect of superimposing a second folding event at a right angle to an existing set of upright folds is the formation of:
(A) Recumbent folds
(B) Isoclinal folds
(C) Dome and basin structures
(D) Monoclines

106. A fault scarp is:
(A) The line of intersection of a fault with the Earth's surface.
(B) A small cliff or step created by fault movement at the surface.
(C) The polished surface of a fault plane.
(D) The crushed rock material found within a fault zone.

107. Which statement about slip and separation is correct?
(A) Slip is the apparent offset, while separation is the true displacement.
(B) Slip and separation are always equal in magnitude.
(C) Separation is the apparent offset seen in a 2D view, while slip is the true 3D displacement vector.
(D) Slip is horizontal displacement, and separation is vertical displacement.

108. The occurrence of systematic joints, often in sets with consistent orientation over a large area, is primarily attributed to:
(A) A regional stress field during tectonic events.
(B) Random fracturing during weathering.
(C) The impact of meteorites.
(D) Burrowing by organisms.

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109. What is the relationship between foliation and lineation?
(A) They are mutually exclusive; a rock can have one or the other, but not both.
(B) Foliation is a type of lineation.
(C) A lineation can be a fabric element that lies within a foliation plane.
(D) Lineation is always perpendicular to foliation.

110. The following question consists of two statements — Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A) : In magma tectonics, cone sheets dip towards a central point.
Reason (R) : Cone sheets are tensional fractures formed by the upward pressure of magma from a central chamber, causing the magma to be injected into fractures that dip inwards.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct

explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

111. A geologist measures a fold and finds its axial plane is vertical and it divides the fold into two mirror-image halves. This fold is best described as:
(A) Asymmetrical and inclined
(B) Recumbent and isoclinal
(C) Overturned and plunging
(D) Symmetrical and upright

112. A type of foliation characterized by alternating layers of light-colored (felsic) and dark-colored (mafic) minerals is known as:
(A) Slaty cleavage
(B) Gneissic banding
(C) Schistosity
(D) Phyllitic sheen

113. According to Anderson's theory, what is the orientation of the intermediate principal stress (σ2) relative to the fault plane and slip direction?
(A) It is parallel to the slip direction.
(B) It is perpendicular to the fault plane.
(C) It is perpendicular to the slip direction and lies within the fault plane.
(D) Its orientation is random.

114. The mechanical principle of rock deformation states that a material's behavior depends on all of the following except:
(A) The rate at which strain is applied.
(B) The ambient temperature and pressure.
(C) The presence and pressure of internal fluids.
(D) The geographic location on Earth's surface.

115. A fault where the hanging wall has moved down relative to the footwall is a:
(A) Normal fault
(B) Reverse fault
(C) Thrust fault
(D) Sinistral fault

116. The recognition of a nonconformity in the field requires identifying:
(A) Tilted sedimentary rocks overlain by horizontal sedimentary rocks.
(B) Parallel sedimentary rocks with a time gap in between.
(C) Sedimentary rocks deposited on top of an eroded surface of older crystalline (igneous or metamorphic) rocks.
(D) A fault that places older rocks over younger rocks.

117. What does the diameter of a Mohr circle represent?
(A) The maximum principal stress (σ1)
(B) The minimum principal stress (σ3)
(C) The average of the principal stresses
(D) The difference between the maximum and minimum principal stresses (σ1 - σ3)

118. A fold hinge that is not horizontal is described as:
(A) Recumbent
(B) Plunging
(C) Upright
(D) Symmetrical

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119. Repetition of strata in a drill core is a strong indication of which type of fault?
(A) Normal fault
(B) Reverse or thrust fault
(C) Dextral strike-slip fault
(D) Sinistral strike-slip fault

120. Match the items in List I with those in List II.
List I: (Term)
P. Hinge
Q. Limb
R. Axial Plane
S. Plunge
List II: (Definition)
1. The sides of a fold
2. The angle of inclination of the fold axis
3. The point or line of maximum curvature
4. The surface connecting hinges of successive layers
Codes:
(A) P-3, Q-1, R-4, S-2
(B) P-1, Q-3, R-2, S-4
(C) P-4, Q-2, R-1, S-3
(D) P-3, Q-1, R-2, S-4

121. Fractures that form in a radial pattern around an uplifting dome or igneous intrusion are a type of:
(A) Shear fracture
(B) Columnar joint

(C) Tensional joint
(D) Conjugate fracture

122. A rock that has been deformed such that it possesses a dominant planar fabric (foliation) but lacks a significant linear fabric is a(n):
(A) S-tectonite
(B) L-tectonite
(C) LS-tectonite
(D) B-tectonite

123. The emplacement of a pluton by forceful injection would most likely result in what kind of structures in the surrounding country rock?
(A) Tensional faults and grabens.
(B) Unaltered horizontal sedimentary layers.
(C) Concordant folding and foliation parallel to the pluton margin.
(D) A large-scale caldera.

124. A strike-slip fault where the opposite block moves to the left is known as:
(A) A dextral fault
(B) A right-lateral fault
(C) A reverse fault
(D) A sinistral fault

125. The 'rule of Vs' is a practical method used in the field for:
(A) Determining the type of faulting.
(B) Estimating the age of an unconformity.
(C) Recognizing folds and determining the direction of dip of strata from map patterns.
(D) Classifying the type of magma tectonics.

126. Consider the following statements and select the correct option.
Statement I : Brittle deformation is favored by high confining pressure.
Statement II : Ductile deformation is favored by high temperature.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is incorrect, but Statement II is correct.
(D) Statement I is correct, but Statement II is incorrect.

127. Which of the following statements about superimposed folding is incorrect?
(A) It results from two or more distinct phases of deformation.
(B) It can produce complex outcrop patterns like domes and basins.
(C) It can be recognized by refolded folds and folded foliations.
(D) The orientation of the second fold set is always parallel to the first.

128. Omission of strata is a key criterion for identifying which type of fault in a stratigraphic section?
(A) Normal fault
(B) Thrust fault
(C) Reverse fault
(D) Strike-slip fault

129. The term used to describe a set of micro-folds that deform an earlier foliation is:
(A) Boudinage
(B) Schistosity
(C) Crenulation
(D) Gneissosity

130. Consider the following statements regarding the mechanics of pluton emplacement:
1. Stoping involves the magma assimilating or displacing blocks of country rock.
2. Diapirism is the process where a buoyant body of magma rises through the crust.
3. Forceful injection involves magma passively filling pre-existing fractures.

Which of the above statement(s) is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

131. In the context of deformation symmetry, a triclinic strain pattern indicates:
(A) The most general, non-symmetrical strain (general shear).
(B) The most symmetrical type of strain (pure shear).
(C) A combination of pure shear and simple shear.
(D) No strain has occurred.

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132. A fold with an inclined axial plane where both limbs dip in the same direction is:
(A) Upright
(B) Overturned
(C) Symmetrical
(D) Recumbent

133. The formation of cone sheets is a direct result of:
(A) Regional extension.
(B) Gravitational collapse of a volcanic edifice.
(C) Upward-directed magmatic pressure from a central intrusion.
(D) Regional compression.

134. Which of these structures is defined by having no discernible displacement across the fracture surface?
(A) Fault
(B) Shear zone
(C) Vein
(D) Joint

135. The concept of progressive deformation implies that:
(A) A rock body undergoes continuous change in shape and orientation during a single tectonic event.
(B) Deformation occurs in several discrete, unrelated events.
(C) Only elastic deformation occurs.
(D) The rock always returns to its original state.

136. What is the fundamental cause of faulting in the Earth's crust?
(A) The chemical weathering of rocks.
(B) The accumulation of stress to the point where it exceeds the rock's strength.
(C) The gravitational pull of the moon.
(D) The radioactive decay within the core.

137. Which of the following is the most reliable feature for determining the direction of slip on a fault plane?
(A) The orientation of slickensides or mineral-fiber lineations.
(B) The thickness of the fault gouge.
(C) The presence of fault breccia.
(D) The dip of the fault plane.

138. In a plunging anticline, where are the oldest rocks exposed after erosion?
(A) Away from the nose, in the core of the fold.
(B) At the nose of the fold, in the direction of plunge.
(C) Along the limbs of the fold.
(D) The age distribution is uniform.

139. A fold with an inter-limb angle between 1° and 10° is classified as:
(A) Open
(B) Gentle
(C) Tight
(D) Isoclinal

140. Arrange the following events in a typical orogenic cycle in chronological order from earliest to latest.
1. Formation of recumbent folds and thrust faults.
2. Uplift, erosion, and deposition of post-orogenic sediments.
3. Development of upright, open folds during later-stage compression.
4. Initial deposition of sedimentary basin strata.

Select the correct answer using the codes given below:
(A) 4, 1, 3, 2
(B) 1, 4, 3, 2
(C) 4, 2, 1, 3
(D) 2, 4, 1, 3

141. The angle that a lineation makes with the horizontal, measured within the foliation plane, is its:
(A) Plunge
(B) Pitch or Rake
(C) Trend
(D) Bearing

142. A monoclinic symmetry of the strain ellipsoid is characteristic of which type of deformation?
(A) Simple shear
(B) Pure shear
(C) Coaxial strain
(D) No deformation

143. Which of the following statements about Unconformity recognition is INCORRECT?
(A) A basal conglomerate directly overlying the surface can indicate an unconformity.
(B) An angular discordance between rock layers

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is a key sign.
(C) Burrows filled with sediment from the overlying layer found in the underlying layer can mark the surface.
(D) A gradual, conformable transition between two rock types indicates an unconformity.

144. In a plunging syncline, how does the outcrop pattern V"?
(A) It forms a U" shape that opens in the direction of plunge.
(B) It V's" in the direction of plunge.
(C) It V's" opposite to the direction of plunge.
(D) It does not form a V" pattern.

145. The following question consists of two statements — Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A) : Joints represent pathways for fluid migration, often leading to enhanced weathering or mineralization.
Reason (R) : Joints are fractures that increase the surface area and permeability of a rock mass.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

146. The horizontal component of net slip on a fault is the:
(A) Dip slip
(B) Strike slip
(C) Throw
(D) Heave

147. A lineation created by the folding of a pre-existing foliation into micro-folds is called:
(A) An intersection lineation
(B) A mineral lineation
(C) A crenulation lineation
(D) A mullion structure

148. What is the cause of faulting?
(A) Gradual accumulation of strain until rock strength is overcome by stress
(B) Regional metamorphism
(C) Chemical dissolution of rock layers
(D) Diagenesis and lithification

149. The mechanics of folding in incompetent, weak layers that are squeezed between strong, competent layers is best described as:
(A) Buckling
(B) Flexural slip
(C) Passive flow folding
(D) Bending

150. Match the items in List I with those in List II.
List I: (Fault Type)
P. Normal Fault
Q. Reverse Fault
R. Strike-Slip Fault
S. Thrust Fault
List II: (Principal Stress Orientation)
1. $\sigma 1$ horizontal, $\sigma 3$ vertical
2. $\sigma 1$ horizontal, $\sigma 2$ vertical
3. $\sigma 1$ vertical, $\sigma 3$ horizontal
4. $\sigma 1$ horizontal, $\sigma 3$ vertical (low angle)
Codes:
(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-1, R-2, S-4
(C) P-2, Q-3, R-1, S-4
(D) P-3, Q-4, R-2, S-1

151. What is the primary mechanical principle behind rock failure?
(A) Applied stress exceeds rock strength under specific conditions.
(B) Applied stress remains significantly below the rock's elastic limit.
(C) Failure occurs exclusively when ambient temperatures are quite high.
(D) Failure is entirely independent of the amount of confining pressure.

152. In three-dimensional strain analysis, if the three principal strain axes (X, Y, Z) are all unequal (X>Y>Z), the strain ellipsoid is:
(A) A triaxial ellipsoid
(B) A prolate spheroid (cigar-shaped)
(C) An oblate spheroid (pancake-shaped)
(D) A sphere

153. What is a key recognition feature of a disconformity?
(A) Angular relationship between upper and lower beds.
(B) An erosional surface separating parallel strata.
(C) Sedimentary rocks overlying crystalline

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rocks.
(D) No visible evidence of a time gap.

154. A fold with a flat crest and two hinge lines is known as a:
(A) Chevron fold
(B) Box fold
(C) Fan fold
(D) Monocline

155. Consider the following statements and select the correct option.
Statement I : Asymmetrical folds have limbs of unequal length.
Statement II : The axial plane of an asymmetrical fold is inclined.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct, but Statement II is incorrect.
(D) Statement I is incorrect, but Statement II is correct.

156. The disappearance or omission" of a stratigraphic layer when viewed in a cliff face or drill core is characteristic of a:
(A) Reverse fault
(B) Thrust fault
(C) Normal fault
(D) Syncline

157. Identify the incorrect statement about strike-slip faults.
(A) They are characterized by dominantly horizontal movement.
(B) A dextral fault is a right-lateral fault.
(C) A sinistral fault is a left-lateral fault.
(D) They are primarily caused by tensional stress.

158. The term 'foliation' is a general term for all of the following EXCEPT:
(A) Slaty cleavage
(B) Schistosity
(C) Gneissic banding
(D) Columnar jointing

159. What is the relationship between rock cleavage and the major stress axes during deformation?
(A) Cleavage tends to form parallel to the maximum principal stress axis (σ1).
(B) Cleavage tends to form perpendicular to the maximum principal stress axis (σ1), in the XY plane of the strain ellipsoid.
(C) Cleavage tends to form at 45 degrees to the maximum principal stress axis (σ1).
(D) The orientation of cleavage is independent of the stress axes.

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160. Consider the following statements about magma tectonics:
1. Ring dykes are formed when magma fills fractures that dip away from a central point.
2. Cone sheets are formed when magma fills fractures that dip towards a central point.
3. Cauldron subsidence is often the underlying mechanism for the formation of ring dykes.

Which of the above statement(s) is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

161. The mechanic process of buckling is most effective in which scenario?
(A) In a sequence of alternating competent and incompetent layers subjected to layer-parallel compression.
(B) In a homogenous, weak rock mass.
(C) In a tensional regime where the crust is being pulled apart.
(D) In a rock mass undergoing partial melting.

162. An LS-Tectonite is a rock that exhibits:
(A) Only a linear fabric.
(B) Only a planar fabric.
(C) Both a planar and a linear fabric.
(D) No deformational fabric.

163. A geologist is examining a large granite body. They note that the metamorphic rocks at the contact are intensely folded and a strong foliation runs parallel to the granite's margin. This suggests the pluton was emplaced by:
(A) Passive stoping
(B) Forceful injection (diapirism)
(C) Cauldron subsidence
(D) Permissive intrusion into a rift zone

164. On a Mohr circle diagram, a state of hydrostatic pressure (where $\sigma1 = \sigma2 = \sigma3$) would be represented by:
(A) A circle with a very large radius.
(B) A single point on the normal stress axis.
(C) A single point on the shear stress axis.
(D) A circle that passes through the origin.

165. The effect of folds on outcrops is that they create distinctive, often repeating, patterns of rock layers. For non-plunging folds, these patterns are:
(A) Linear and parallel to the fold axis
(B) Circular
(C) Elliptical
(D) Random

166. Which type of fault is characteristic of continental rift zones, such as the East African Rift Valley?
(A) Thrust faults
(B) Reverse faults
(C) Normal faults
(D) Sinistral strike-slip faults

167. Identify the correct pair.
(A) Anticline - Youngest rocks in the core
(B) Syncline - Oldest rocks in the core
(C) Nonconformity - Sedimentary rocks on crystalline rocks
(D) Disconformity - Angular relationship between beds

168. The difference between slip and separation is crucial because:
(A) Separation gives the true movement direction, while slip does not.
(B) Slip can only be measured in strike-slip faults.
(C) Separation is an apparent offset in a 2D view and can be misleading about the true nature and magnitude of fault movement (slip).
(D) Slip is vertical, and separation is horizontal.

169. What is a key characteristic of a superimposed fold?
(A) It involves the folding of an earlier-formed fold or foliation.
(B) It has a perfectly horizontal axial plane.
(C) It is always symmetrical.
(D) It only occurs in igneous rocks.

170. Which of the following is an indicator of the top direction of a sedimentary bed, useful in deciphering folded structures?
(A) Slaty cleavage
(B) Gneissic banding
(C) Graded bedding
(D) Mineral lineation

171. A lineation is defined as:
(A) Any linear, directional fabric element in a rock.
(B) Any planar feature in a rock.
(C) A type of fault.
(D) The trace of a bedding plane on the surface.

172. The presence of numerous angular fragments of wall rock suspended in a granitic pluton near its margin is evidence for which emplacement mechanism?
(A) Stoping
(B) Diapirism
(C) Flexural slip
(D) Buckling

173. In Anderson's classification, a tectonic regime dominated by horizontal compression (e.g., continental collision) would produce:
(A) Normal faults
(B) Reverse and thrust faults
(C) A mix of normal and strike-slip faults
(D) Graben structures

174. A fold is described as 'recumbent' when its:
(A) Axial plane is vertical.
(B) Hinge line is vertical.
(C) Limbs are parallel.
(D) Axial plane is horizontal or near-horizontal.

175. The following question consists of two statements — Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A) : A nonconformity represents a significant amount of missing geologic time.
Reason (R) : It involves the uplift and erosion of deep-seated metamorphic or igneous rocks before they are covered by younger sediments.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.

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(C) A is true but R is false.
(D) A is false but R is true.

176. Which condition promotes ductile deformation over brittle failure?
(A) Low temperature
(B) High strain rate
(C) Low confining pressure
(D) High temperature

177. A 'window' or 'fenster' is a geological feature associated with which type of structure?
(A) A normal fault
(B) A large-scale thrust fault
(C) An upright syncline
(D) A salt dome

178. The classification of folds based on the tightness of their limbs (e.g., open, tight, isoclinal) depends on the:
(A) Plunge of the fold axis
(B) Inter-limb angle
(C) Dip of the axial plane
(D) Wavelength of the fold

179. The term that describes the alignment of platy minerals like mica and chlorite to create a planar fabric in metamorphic rocks is:
(A) Lineation
(B) Bedding
(C) Foliation
(D) Jointing

180. Match the items in List I with those in List II.
List I: (Evidence)
P. Repetition of strata in a vertical drill hole
Q. Omission of strata in a vertical drill hole
R. Angular discordance between two sedimentary units
S. Sedimentary rocks overlying granite
List II: (Structure Indicated)
1. Angular Unconformity
2. Normal Fault
3. Nonconformity
4. Thrust Fault
Codes:
(A) P-4, Q-2, R-1, S-3
(B) P-2, Q-4, R-1, S-3
(C) P-4, Q-2, R-3, S-1
(D) P-1, Q-2, R-4, S-3

181. What does the failure envelope on a Mohr diagram represent?
(A) Shear and normal stress conditions required to fracture a rock.
(B) The conditions of stress under which the rock will deform elastically.
(C) The specific path of progressive deformation within a tectonic zone.
(D) The magnitude of the intermediate principal stress in a 3D system.

182. If a fold's axial plane is inclined, and the limbs dip in opposite directions, the fold is:
(A) Upright and symmetrical
(B) Recumbent
(C) Overturned
(D) Inclined and asymmetrical

183. Consider the following statements and select the correct option.
Statement I : Ring dykes are typically circular or arcuate in plan view.
Statement II : Ring dykes form by the intrusion of magma along conical fractures that dip outwards from a center.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct, but Statement II is incorrect.
(D) Statement I is incorrect, but Statement II is correct.

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184. The distinction between a joint and a fault is based on:
(A) The orientation of the fracture.
(B) The type of rock they occur in.
(C) The age of the fracture.
(D) The presence or absence of measurable displacement across the fracture.

185. Flexural slip is a mechanism of folding that is most analogous to:
(A) Bending a deck of playing cards.
(B) Squeezing a tube of toothpaste.
(C) Stretching a rubber band.
(D) Shattering a piece of glass.

186. Which of the following is not a recognized type of unconformity?

(A) Disconformity
(B) Nonconformity
(C) Conformity
(D) Paraconformity

187. In a region of active crustal extension, one would most expect to find:
(A) Normal faults and grabens
(B) Thrust faults and folding
(C) Dextral and sinistral strike-slip faults
(D) Recumbent folds

188. A fabric element that is linear in three dimensions is known as a:
(A) Lineation
(B) Foliation
(C) Cleavage
(D) Schistosity

189. A dome structure is best described as:
(A) An anticline that plunges in all directions away from a central point.
(B) A syncline that plunges in two opposite directions.
(C) A basin that is uplifted.
(D) A fold with a horizontal axis.

190. Consider the following statements about structural features:
1. A fault is a fracture along which there has been significant displacement.
2. A joint is a fracture with no significant displacement.
3. A foliation is a planar fabric resulting from the alignment of mineral grains.

Which of the above statement(s) is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

191. The concept that the orientation of $\sigma 1$, $\sigma 2$, and $\sigma 3$ determines the type of faulting is central to:
(A) Ramsay's fold classification
(B) The V-rule of outcrops
(C) Anderson's theory of faulting
(D) The principle of superposition

192. A klippe is an erosional remnant of a:
(A) Normal fault sheet
(B) Volcanic crater rim
(C) Thrust sheet (nappe)
(D) Synclinal core

193. The term 'stress' in geology is an example of:
(A) A scalar quantity
(B) A vector quantity
(C) A tensor quantity
(D) An abstract concept with no physical meaning

194. A geologist observes sedimentary layers dipping at 20° East. An igneous dyke cuts through these layers. By the principle of cross-cutting relationships, the dyke is:
(A) Younger than the sedimentary layers
(B) Older than the sedimentary layers
(C) The same age as the sedimentary layers
(D) Unrelated in age to the sedimentary layers

195. The angle between a fold's hinge line and a horizontal plane is the:
(A) Strike
(B) Plunge
(C) Dip
(D) Rake

196. A basin structure, when eroded, will expose what relative age of rocks at its center?
(A) Youngest
(B) Oldest
(C) A mixture of ages
(D) Only igneous rocks

197. Which of the following is not a primary mechanism of pluton emplacement?
(A) Stoping
(B) Diapirism
(C) Forceful injection
(D) Subduction

198. The mechanical behavior of a rock that deforms by fracturing is called:
(A) Brittle
(B) Ductile
(C) Plastic
(D) Elastic

199. A lineation formed by the parallel alignment of needle-like minerals such as amphiboles is a:
(A) Mineral lineation
(B) Crenulation lineation

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(C) Boudinage
(D) Intersection lineation

200. Place the following rock fabrics in order of increasing metamorphic grade.
1. Gneissic banding
2. Slaty cleavage
3. Schistosity
Select the correct answer using the codes given below:
(A) 1, 2, 3
(B) 2, 3, 1
(C) 3, 2, 1
(D) 2, 1, 3

201. The 'separation' of a faulted bed refers to:
(A) The apparent offset of the bed in a specific 2D view (e.g., a cliff face).
(B) The true, 3D displacement vector.
(C) The distance between the hanging wall and footwall.
(D) The amount of gouge material produced.

202. Which of these is a mechanism of ductile deformation?
(A) Recrystallization and intracrystalline slip
(B) Fracture
(C) Faulting
(D) Jointing

203. A monoclinic symmetry of movement is characteristic of:
(A) Simple shear
(B) Pure shear
(C) Compaction
(D) Hydrostatic compression

204. The recognition of a fault in the field is often aided by the presence of all the following EXCEPT:
(A) A fault scarp
(B) Slickensides on a rock surface
(C) The juxtaposition of different rock types
(D) Perfectly parallel and continuous sedimentary layers

205. Consider the following statements and select the correct option.
Statement I : Ring dykes are vertical or steeply dipping intrusions that are circular in plan.
Statement II : Cone sheets are intrusions that dip inwards toward a common focal point.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct, but Statement II is incorrect.
(D) Statement I is incorrect, but Statement II is correct.

206. A fold's 'style' (e.g., parallel, similar) is a classification based on:
(A) The variation in thickness of the folded layers.
(B) The orientation of its axial plane.
(C) The angle of plunge.
(D) The age of the rocks involved.

207. Which of the following best describes schistosity?
(A) A coarse-grained foliation defined by the parallel alignment of visible platy minerals.
(B) A fine-grained foliation in slate, developed at low metamorphic grade.
(C) A compositional banding of light and dark minerals in gneiss.
(D) A set of systematic fractures in an igneous rock.

208. The 'throw' of a fault is the:
(A) Vertical component of dip slip.
(B) Horizontal component of dip slip.
(C) Total net slip.
(D) Horizontal component of strike slip.

209. What is the fundamental control on whether folding or faulting occurs?
(A) The conditions of pressure, temperature, and strain rate which determine if the rock behaves ductilely or brittly.
(B) The color of the rock.
(C) The fossil content of the rock.
(D) The presence of groundwater.

210. The following question consists of two statements — Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A) : The outcrop pattern of a plunging anticline V's" or closes in the direction of plunge.
Reason (R) : As the plunging anticline is

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eroded, the dipping limbs on either side of the axis converge in the direction the axis is plunging.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

211. What is a paraconformity?
(A) An unconformity where sedimentary rocks overlie crystalline rocks.
(B) An unconformity characterized by a distinct angular discordance.
(C) Parallel strata with a non-erosional contact and a time gap.
(D) Younger strata deposited against older strata in an ancient valley.

212. In a Mohr circle representation of stress, what does the radius of the circle equal?
(A) The maximum principal stress, $\sigma 1$.
(B) The average stress, $(\sigma 1+\sigma 3)/2$.
(C) The maximum shear stress, $(\sigma 1-\sigma 3)/2$.
(D) The confining pressure, $\sigma 3$.

213. The process of superimposing a new set of folds onto an existing set of folds can result in:
(A) Interference patterns.
(B) Uniform, parallel bedding.
(C) The formation of an unconformity.
(D) The complete erasure of the first set of folds.

214. Which structure results from compressional stress and brittle failure?
(A) Normal fault
(B) Syncline
(C) Joint
(D) Reverse fault

215. A linear arrangement of elongated pebbles in a deformed conglomerate is an example of:
(A) Lineation
(B) Foliation
(C) Bedding
(D) A joint set

216. The emplacement of magma by stoping involves:
(A) The forceful pushing aside of country rock.
(B) The buoyant rise of the magma body.
(C) The fracturing and assimilation of overlying country rock.
(D) The filling of a pre-existing cave system.

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217. Identify the incorrect statement regarding rock deformation.
(A) Higher ambient temperature always promotes rock ductility.
(B) Higher confining pressure usually promotes rock ductility.
(C) Slower strain rates typically promote greater rock ductility.
(D) Mineral composition has no influence on mechanical behavior.

218. The line of intersection between a fault plane and the Earth's surface is the:
(A) Fault trace
(B) Fault scarp
(C) Slickenside
(D) Hinge line

219. A 'similar' fold is characterized by:
(A) Constant layer thickness measured perpendicular to bedding.
(B) Thinning of limbs and thickening of hinges.
(C) Straight limbs and sharp hinges.
(D) A horizontal axial plane.

220. Match the items in List I with those in List II.
List I: (Term)
P. Unconformity
Q. Fault
R. Fold
S. Pluton Emplacement
List II: (Associated Feature)
1. Hinge and Limb
2. Stoping and Diapirism
3. Basal Conglomerate
4. Slickensides and Gouge
Codes:
(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-4, R-1, S-2
(C) P-4, Q-3, R-2, S-1
(D) P-3, Q-1, R-4, S-2

221. A rock that has been strained such that an original sphere becomes a flattened, pancake-like ellipsoid has undergone:
(A) Uniaxial flattening
(B) Uniaxial stretching

(C) Simple shear
(D) No strain

222. An unconformity is fundamentally a:
(A) Surface representing a gap in the geologic record (a period of non-deposition or erosion).
(B) Type of fault
(C) Type of fold
(D) Feature formed by magma intrusion.

223. What is the key difference between a plunging and a non-plunging fold?
(A) The orientation of the hinge line (inclined vs. horizontal).
(B) The tightness of the limbs.
(C) The symmetry of the fold.
(D) The age of the rocks in the core.

224. The repetition of rock units in a sequence such as A-B-C-D-B-C-D-E-F is indicative of:
(A) A normal fault
(B) An overturned fold or a thrust fault
(C) An unconformity
(D) A simple syncline

225. A strike-slip fault that also has a component of normal fault motion is called a:
(A) Transpirational fault
(B) Trans tensional fault
(C) Transverse fault
(D) Transform fault

226. Consider the following statements and select the correct option.
Statement I : Joints and fractures can significantly increase the secondary porosity and permeability of a rock.
Statement II : Slaty cleavage develops in high-grade metamorphic rocks like gneiss.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct, but Statement II is incorrect.
(D) Statement I is incorrect, but Statement II is correct.

227. The mechanics of faulting is directly related to the concept of:
(A) Rock failure as described by the Mohr-Coulomb failure criterion.
(B) The principle of faunal succession.
(C) The process of radioactive decay.
(D) The laws of thermodynamics.

228. A tectonic fabric describes:
(A) The geometric arrangement of mineral grains and internal structures resulting from deformation.
(B) The mineral composition of a rock.
(C) The depositional texture of a sedimentary rock.
(D) The age of a rock determined by isotopic dating.

229. The formation of ring dykes and cone sheets is fundamentally a part of:
(A) Magma tectonics
(B) Regional metamorphism
(C) Sedimentary basin development
(D) Orogen-scale folding

230. Consider the following statements about folds:
1. An anticline is a fold that is convex upward.
2. A syncline has the youngest rocks in its core.
3. A monocline is a single, steeply-dipping fold limb.

Which of the above statement(s) is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

231. The point on the Mohr circle furthest to the right on the normal stress axis represents:
(A) The maximum principal stress ($\sigma 1$)
(B) The minimum principal stress ($\sigma 3$)
(C) The maximum shear stress
(D) The tensile strength of the rock

232. In an area with multiple deformations, how might a geologist distinguish a younger fold set from an older one?
(A) The younger fold set will deform the axial planes and limbs of the older fold set.
(B) The younger fold set will always be larger.
(C) The older fold set will always be tighter.
(D) The younger fold set will contain older rocks.

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233. The cause of faulting is the buildup of stress in the lithosphere. This stress is primarily generated by:
(A) Ocean tides
(B) Plate tectonics
(C) Solar radiation
(D) Earth's magnetic field

234. An 'oblique-slip' fault is one that shows:
(A) A combination of strike-slip and dip-slip movement
(B) Only vertical movement
(C) Only horizontal movement
(D) No movement at all

235. The term for a very fine-grained, clay-rich, incohesive material found within a fault zone is:
(A) Breccia
(B) Mylonite
(C) Gouge
(D) Cataclasite

236. The term 'foliation' applies to a planar fabric in which type of rock?
(A) Metamorphic
(B) Sedimentary
(C) Igneous
(D) All of the above

237. In the mechanics of folding, competent layers tend to _____, while incompetent layers tend to _____.
(A) buckle; flow
(B) flow; buckle
(C) fracture; melt
(D) melt; fracture

238. A rock fabric dominated by linear elements is an L-tectonite. This fabric is typically produced by what type of strain?
(A) Pure constriction (prolate strain)
(B) Pure flattening (oblate strain)
(C) Simple shear
(D) Compaction

239. The forceful emplacement of a salt dome (a type of diapir) is a good analogue for the magma tectonic process of:
(A) Diapirism
(B) Stoping
(C) Cauldron subsidence
(D) Cone sheet injection

240. The following question consists of two statements — Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A) : Slaty cleavage is characteristic of fine-grained rocks deformed under low metamorphic grade.
Reason (R) : It forms by the mechanical rotation and pressure solution-aided recrystallization of clay minerals into parallel mica flakes.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

241. What is the primary difference between stress and strain?
(A) Stress is force per unit area; strain is the resulting deformation or change in shape.
(B) Stress is a change in shape; strain is a force.
(C) Stress and strain are identical concepts.
(D) Stress is measured in percent; strain is measured in Pascals.

242. An unconformity separating horizontal sedimentary rocks from underlying tilted sedimentary rocks is a(n):
(A) Angular unconformity
(B) Disconformity
(C) Nonconformity
(D) Paraconformity

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243. In a fold, the 'limbs' are the:
(A) Points of maximum curvature.
(B) Sides or flanks of the fold between the hinges.
(C) Line connecting the deepest parts of a syncline.
(D) Imaginary plane dividing the fold symmetrically.

244. A large-scale recumbent fold is also known as a:
(A) Nappe
(B) Graben
(C) Horst
(D) Dome

245. The recognition of a strike-slip fault in the field would be most aided by observing:
(A) Horizontally offset features like streams or fences.
(B) Repetition of strata.
(C) Omission of strata.
(D) A large vertical cliff.

246. Which of these terms is NOT a type of lineation?
(A) Mineral alignment
(B) Schistosity
(C) Slickenside striae
(D) Intersection of two planar fabrics

247. The mechanics of folding is a study of:
(A) How rock layers bend and deform to form folds.
(B) How faults displace rock layers.
(C) How magma is emplaced in the crust.
(D) How sediments are deposited.

248. According to Anderson's theory, normal faults form when:
(A) $\sigma 1$ is horizontal, $\sigma 3$ is vertical.
(B) $\sigma 1$ is vertical, $\sigma 3$ is horizontal.
(C) $\sigma 2$ is vertical, $\sigma 1$ is horizontal.
(D) $\sigma 2$ is horizontal, $\sigma 3$ is vertical.

249. Cauldron subsidence is a mechanism primarily related to:
(A) The collapse of the roof of a magma chamber.
(B) The forceful rise of a pluton.
(C) The development of a rift valley.
(D) The collision of two continents.

250. Match the items in List I with those in List II.
List I: (Concept)
P. Stress
Q. Strain
R. Ductility
S. Brittleness
List II: (Description)
1. The property of deforming without fracturing
2. The property of fracturing at low strain
3. Force per unit area
4. Change in shape or volume
Codes:
(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-4, R-2, S-1
(C) P-3, Q-4, R-1, S-2
(D) P-4, Q-3, R-1, S-2

251. The state of stress at a point in 2D can be graphically visualized using a:
(A) Stereonet
(B) Rose diagram
(C) Mohr Circle
(D) Strain ellipse

252. A fold with an inter-limb angle greater than 120° is classified as:
(A) Gentle
(B) Open
(C) Tight
(D) Isoclinal

253. Consider the following statements and select the correct option.
Statement I : The hanging wall moves up relative to the footwall in a reverse fault.
Statement II : Reverse faults result from tensional stress.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct, but Statement II is incorrect.
(D) Statement I is incorrect, but Statement II is correct.

254. A fracture cleavage is different from a slaty cleavage in that:
(A) It is a set of discrete, parallel micro-fractures, not a pervasive mineral fabric.
(B) It is defined by the alignment of new minerals.
(C) It only forms in high-grade metamorphic rocks.
(D) It is always perpendicular to bedding.

255. A fold is described as 'isoclinal' when its:
(A) Axial plane is horizontal.
(B) Limbs are parallel to one another.
(C) Hinge is very sharp and angular.
(D) Limbs are of unequal length.

256. The main cause of joint formation is often related to stress release from:
(A) Erosion of overlying rock (unloading).

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(B) Cooling and contraction of an igneous body.
(C) Tectonic stresses.
(D) All of the above.

257. A 'window' or 'fenster' is an erosional hole through a _____, which exposes the _____ underneath.
(A) thrust sheet; footwall rocks
(B) normal fault; hanging wall rocks
(C) syncline; anticline
(D) volcanic cone; magma chamber

258. Identify the incorrect statement about strike-slip faults.
(A) They are characterized by dominantly horizontal movement.
(B) A dextral fault is a right-lateral fault.
(C) A sinistral fault is a left-lateral fault.
(D) They are primarily caused by tensional stress.

259. A geologist identifies a sequence of rocks where Paleozoic sedimentary rocks rest directly on Precambrian granite. This contact is a:
(A) Disconformity
(B) Para conformity
(C) Fault
(D) Nonconformity

260. Consider the following statements about fault classification:
1. A fault is classified as dip-slip if the movement is parallel to the dip of the fault plane.
2. A fault is classified as strike-slip if the movement is parallel to the strike of the fault plane.
3. An oblique-slip fault has components of both dip-slip and strike-slip motion.

Which of the above statement(s) is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

261. The outcrop pattern of a vertically dipping bed on a topographic map will be:
(A) A straight line that is unaffected by topography.
(B) A line that V's" in the direction of dip when crossing valleys.
(C) A line that perfectly follows the contour lines.
(D) A circular pattern.

262. Which of these is a mechanism of ductile deformation?
(A) Recrystallization and intra crystalline slip
(B) Fracture
(C) Faulting
(D) Jointing

263. The symmetry concept in deformation is useful for inferring:
(A) The movement picture or kinematics of the deformation.
(B) The age of the rock.
(C) The temperature of formation.
(D) The mineral composition.

264. An anticline that plunges will have an outcrop pattern on a map that is:
(A) A U-shape or V-shape that closes in the direction of plunge.
(B) A set of parallel lines.
(C) A U-shape or V-shape that opens in the direction of plunge.
(D) A perfect circle.

265. What is the difference between heave and throw?
(A) Heave is strike-slip; throw is dip-slip.
(B) Heave is the horizontal component of dip-slip; throw is the vertical component.
(C) Heave is vertical displacement; throw is horizontal.
(D) There is no difference.

266. A linear structure formed by the corrugation of a foliation plane is a:
(A) Mineral lineation
(B) Boudin
(C) Crenulation
(D) Stylolite

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267. Consider the following statements and select the correct option.
Statement I : The mechanics of folding involves both buckling and bending mechanisms.
Statement II : The mechanics of faulting is explained by Anderson's theory relating stress state to fault type.

(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct, but Statement II is incorrect.
(D) Statement I is incorrect, but Statement II is correct.

268. A pluton that is concordant with the country rock fabric, suggesting it pushed the rocks aside, was likely emplaced by:
(A) Forceful injection
(B) Stoping
(C) Cauldron subsidence
(D) Passive filling

269. A fault in which the dip of the fault plane decreases with depth is called a:
(A) Listric fault
(B) Planar fault
(C) Vertical fault
(D) Transform fault

270. The following question consists of two statements — Assertion (A) and Reason (R). Answer the question by selecting the appropriate option.
Assertion (A) : Joints are the most common type of geologic structure.
Reason (R) : They can form in any rock type due to a variety of causes including cooling, unloading, and tectonic stresses, which are widespread processes.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

271. An increase in pore fluid pressure in a rock has what effect on its strength?
(A) It reduces the effective normal stress, thereby reducing the rock's shear strength and promoting failure.
(B) It increases the rock's strength by cementing grains.
(C) It has no effect on the rock's strength.
(D) It increases the temperature, making the rock more ductile.

272. A fold with an axial plane dipping at an angle between 10° and 80° is classified as:
(A) Inclined
(B) Upright
(C) Recumbent
(D) Vertical

273. The outcrop pattern of a plunging syncline:
(A) Opens in the direction of plunge.
(B) Closes or V's" in the direction of plunge.
(C) Forms parallel bands.
(D) Is always circular.

274. A strike-slip fault that forms the boundary between two tectonic plates, such as the San Andreas Fault, is a:
(A) Transform fault
(B) Normal fault
(C) Thrust fault
(D) Growth fault

275. A foliation defined by the preferred orientation of inequant mineral grains is a key feature of:
(A) Deformed metamorphic rocks.
(B) Unconsolidated sediments.
(C) Freshly cooled lava.
(D) Chemically precipitated limestone.

276. The emplacement of a batholith by assimilating and sinking large blocks of the overlying rock is the process of:
(A) Stoping
(B) Diapirism
(C) Forceful injection
(D) Lopolith formation

277. The 'heave' of a fault is defined as the:
(A) Horizontal component of dip-slip.
(B) Vertical component of dip-slip.
(C) Horizontal component of strike-slip.
(D) Total net slip.

278. Which of the following is NOT a type of foliation?
(A) Slaty cleavage
(B) Schistosity
(C) Gneissic layering
(D) Intersection lineation

279. In a compressional tectonic setting, which structures would be most common?

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(A) Normal faults, horsts, and grabens.
(B) Folds, reverse faults, and thrust faults.
(C) Strike-slip faults and transform boundaries.
(D) Ring dykes and cone sheets.

280. Match the items in List I with those in List II.
List I: (Structure Type)
P. Anticline
Q. Syncline
R. Dome
S. Basin
List II: (Geometric Shape)
1. A fold that is concave up
2. An antiform that closes in all directions
3. A synform that closes in all directions
4. A fold that is convex up
Codes:
(A) P-1, Q-4, R-3, S-2
(B) P-4, Q-1, R-3, S-2
(C) P-4, Q-1, R-2, S-3
(D) P-1, Q-4, R-2, S-3

281. The Mohr-Coulomb failure criterion describes the relationship between:
(A) Shear stress and normal stress required for a brittle fracture.
(B) Stress and strain.
(C) Temperature and pressure.
(D) Time and deformation.

282. The recognition of a paraconformity is most dependent on:
(A) The identification of a basal conglomerate at the contact zone.
(B) A visible erosional surface separating two parallel rock units.
(C) Paleontological evidence indicating a significant time gap.
(D) The presence of a distinct angular discordance between layers.

283. What is the effect of superimposing a later deformation on an earlier set of folds?
(A) It creates complex interference patterns and refolded folds.
(B) It always erases the earlier folds.
(C) It anneals the rock, removing all structures.
(D) It only affects the limbs, not the hinges of the earlier folds.

284. Which of the following is a criterion for recognizing a fault?
(A) Juxtaposition of different rock types or ages that are not in normal stratigraphic order.
(B) Gradual change in lithology.
(C) Presence of graded bedding.
(D) Symmetrical rock layers.

285. A lineation resulting from the alignment of the long axes of minerals like hornblende is a:
(A) Mineral lineation
(B) Fracture cleavage
(C) Schistosity
(D) Crenulation

286. Which mechanism of folding involves layer-parallel shortening and is often modeled by compressing a deck of cards from the ends?
(A) Buckling
(B) Bending
(C) Passive flow
(D) Flexural slip

287. A rock fabric that has both a strong foliation and a strong lineation is called a(n):
(A) LS-tectonite
(B) S-tectonite
(C) L-tectonite
(D) Isotropic fabric

288. Cone sheets are thought to form in which stress regime?
(A) A regional compressional field associated with plate convergence.
(B) A regional tensional field related to active continental rifting.
(C) A regional shear field found along major transform fault boundaries.
(D) Upward pressure from a magma chamber forming tensional fractures.

289. The block of rock below a non-vertical fault plane is the:
(A) Footwall
(B) Hanging wall
(C) Fault scarp
(D) Klippe

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290. Consider the following statements about folds and their recognition:
1. In an anticline, rock layers dip away from

the center axis.
2. In a syncline, rock layers dip toward the center axis.
3. The outcrop pattern of non-plunging folds consists of parallel bands.

Which of the above statement(s) is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

291. What is the primary cause of the formation of columnar joints in basaltic lavas?
(A) Tensional stresses created during the cooling and contraction of the lava.
(B) Tectonic compression
(C) Rapid burial and compaction.
(D) Shear stress during flow.

292. The complete state of stress at a point in three dimensions is defined by:
(A) The three principal stresses ($\sigma 1$, $\sigma 2$, $\sigma 3$) and their orientations.
(B) A single value of pressure.
(C) The rock's unconfined compressive strength.
(D) The direction of gravity.

293. An unconformity represents:
(A) A surface of erosion or non-deposition.
(B) Continuous deposition.
(C) A fault with large displacement.
(D) A zone of intense folding.

294. A fold in which the axial plane is essentially horizontal is a:
(A) Recumbent fold
(B) Upright fold
(C) Monocline
(D) Isoclinal fold

295. Arrange the following fault-related rocks in order from lowest to highest degree of deformation and/or depth.
1. Fault Gouge
2. Mylonite
3. Fault Breccia
4. Pseudotachylite

Select the correct answer using the codes given below:
(A) 1, 3, 2, 4
(B) 3, 1, 2, 4
(C) 2, 4, 1, 3
(D) 3, 2, 1, 4

296. A 'sinistral' fault is a type of:
(A) Left-lateral strike-slip fault
(B) Normal fault
(C) Reverse fault
(D) Right-lateral strike-slip fault

297. Consider the following statements and select the correct option.
Statement I : Foliation is a planar tectonic fabric.
Statement II : Lineation is a linear tectonic fabric.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct, but Statement II is incorrect.
(D) Statement I is incorrect, but Statement II is correct.

298. The mechanism of folding where layers slip past one another is termed:
(A) Buckling
(B) Passive flow
(C) Bending
(D) Flexural slip

299. The tectonic fabric" of a rock refers to:
(A) The geometric arrangement of its constituent parts as a result of deformation.
(B) Its chemical composition.
(C) Its grain size and sorting.
(D) Its absolute age.

300. The buoyant rise of a less dense magmatic body through more dense surrounding rock is a pluton emplacement mechanism known as:
(A) Stoping
(B) Diapirism
(C) Cauldron subsidence
(D) Cone sheet injection

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ANSWERS

1. (B) Stress
Stress represents the internal resistance within a material to an external force, measured specifically as force per unit surface area. It reflects the intensity of the force acting on rock bodies during tectonic events. This physical quantity is essential for understanding how geological structures like faults and folds develop in response to the massive lithospheric pressures applied over time.

2. (A) Strain
Strain represents the deformation experienced by a rock body in response to applied stress. It is characterized by changes in the shape, volume, or length of the geological material. Unlike stress, which is the causal force, strain is the measurable effect or result of that force, manifesting as folding, stretching, or fracturing within the crustal layers.

3. (C) High confining pressure reduces fracturing and increases ductility
Confining pressure significantly influences the mechanical behavior of rocks at depth. Increasing the weight of overlying material compresses the rock from all directions, which inhibits the formation and propagation of fractures. Consequently, higher confining pressures transition a rock from a brittle state to a ductile one, allowing it to flow or bend rather than snap under tectonic stress.

4. (D) Ductile strain
Ductile strain occurs when a rock undergoes permanent deformation without losing its internal cohesion or fracturing. When subjected to compressional stress, rocks in a ductile state will typically shorten along the axis of maximum stress and thicken in the perpendicular direction. This behavior is common in high-temperature, high-pressure environments deep within the Earth's crustal layers.

5. (A) P-3, Q-4, R-2, S-1
Elastic deformation is temporary and recoverable, meaning the rock returns to its original shape once stress is removed. Plastic deformation causes permanent change without fracturing, while brittle deformation results in breakage. Viscous deformation involves permanent flow over time. These different mechanical responses depend on the physical properties of the rock and the conditions under which the stress is applied.

6. (C) Statement I is correct, but Statement II is incorrect
Stress is the external force applied to a rock, making it the cause of deformation, while strain is the resulting change in shape, acting as the effect. However, rocks do not exhibit identical mechanical behavior under the same stress conditions. Their responses vary significantly based on mineral composition, temperature, confining pressure, and the rate at which stress is applied.

7. (D) $\sigma 1$ always represents the minimum compressive stress
Principal stresses act on planes where shear stress is zero and are mutually perpendicular in three-dimensional space. The state of stress at any point can be visualized using a stress ellipsoid. In the standard convention, sigma-one represents the maximum compressive stress, not the minimum. Therefore, characterizing sigma-one as the minimum stress is a fundamentally incorrect description of these parameters.

8. (A) High confining pressure
Brittle behavior is characterized by fracturing and loss of cohesion, which is favored by low temperatures, high strain rates, and low fluid pressures. Conversely, high confining pressure acts to keep the rock together, effectively inhibiting fracture formation and promoting ductile flow. Therefore, high confining pressure is a factor that discourages brittle failure and instead encourages the rock to deform plastically.

9. (C) It acts to close any micro cracks that might form
Confining pressure represents the equal pressure exerted on a rock from all sides due to burial

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depth. This pressure increases the friction between mineral grains and acts to close any microcracks that begin to form under stress. By preventing these cracks from propagating and joining, high confining pressure effectively inhibits brittle fracturing, forcing the rock to deform by ductile flow.

10. (A) Both A and R are true and R is the correct explanation of A
In a Mohr circle diagram, the center is always located on the normal stress axis because the circle represents states of stress where shear stress becomes zero at the principal stress points. The circle provides a graphical visualization of how shear and normal stresses change with orientation. Both the geometric property and the underlying physical principles are accurately represented here.

11. (D) An angular unconformity
An angular unconformity is a structural feature where older, tilted or folded sedimentary strata are overlain by younger, relatively horizontal layers. The presence of a basal conglomerate at the contact surface indicates an erosional period before the new deposition began. This discordance represents a significant gap in the geological record, highlighting a sequence of uplift, deformation, and erosion.

12. (B) A sphere deformed into an ellipsoid as a rock undergoes strain
The strain ellipsoid is a mathematical and geometric tool used to visualize the state of strain at a point within a rock. It represents the shape that an imaginary, perfectly spherical volume of rock takes after it has undergone deformation. By comparing the dimensions of the final ellipsoid to the original sphere, geologists can determine the direction and magnitude of strain.

13. (C) Triclinic symmetry - No planes or axes of symmetry
Triclinic symmetry represents the most general and least symmetrical form of deformation, where no planes or axes of symmetry exist within the fabric of the rock. This typically occurs during general shear where deformation is highly non-coaxial. In contrast, monoclinic symmetry has one plane, and orthorhombic symmetry has three mutually perpendicular planes, reflecting more structured and systematic strain environments.

14. (D) Progressive deformation
Progressive deformation describes a continuous process where a rock body undergoes a sequence of changes in shape, size, and orientation over a period of time. It involves a single, ongoing tectonic event rather than multiple isolated episodes. This concept is vital for understanding how complex structures like folded mountain belts evolve from initially horizontal strata through sustained and evolving stress.

15. (A) 1 and 2 only
A nonconformity occurs when younger sedimentary strata are deposited on an eroded surface of much older igneous or metamorphic rocks. A disconformity represents an erosional gap between parallel sedimentary layers. However, a paraconformity lacks visible angular discordance or an obvious erosion surface, making it difficult to identify without fossil evidence. Thus, only the first two descriptions of unconformities are correct.

16. (B) The surface that connects the hinge lines of successive folded layers
The axial plane is a planar or curved surface that connects the hinge lines of all the individual layers within a fold. It essentially bisects the fold, dividing it into two limbs. The orientation of this plane is a key criterion for classifying folds, as it can be vertical, inclined, or horizontal, reflecting the direction of the compressional forces that created them.

17. (B) The hinge line is the line of minimum curvature on a fold surface
In fold geometry, the hinge line is actually defined as the line of maximum curvature on a folded surface, where the rock layers turn most sharply. The limbs are the flanking regions on either side of this hinge. Anticlines are folds where the layers are convex upward, while synclines are concave upward. Identifying the hinge line is essential for structural mapping.

18. (A) An overturned fold
An overturned fold is characterized by an inclined axial plane where both limbs dip in the same direction. This occurs because one limb has

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been rotated past the vertical position, making it stratigraphically upside down. This structure indicates intense compressional stress and significant crustal shortening, often found in the complex internal zones of mountain belts where deformation is particularly severe.

19. (A) Both Statement I and Statement II are correct
In a non-plunging anticline, the rock layers are arched upward, so erosion exposes the oldest strata along the central axis or core. Conversely, in a non-plunging syncline, the layers are bowed downward, which results in the youngest rocks being preserved and exposed in the core. These age relationships are fundamental for identifying fold types in the field during geological mapping.

20. (A) 1, 3, 4, 2
During a single progressive deformational event, folds typically evolve from gentle forms with large inter-limb angles to more compressed shapes. The sequence begins with gentle folds, followed by open folds, then tight folds, and eventually isoclinal folds where the limbs become parallel. This progression reflects the increasing amount of strain and crustal shortening accommodated by the rock layers as deformation continues.

21. (C) Recumbent fold
A recumbent fold is a type of fold where the axial plane is horizontal or nearly horizontal. This indicates that the fold has been pushed over onto its side due to extreme compressional forces. In such structures, the limbs are typically horizontal, and one limb is completely overturned, representing a high degree of tectonic transport and deformation within a mountain-building environment.

22. (B) In the direction of dip
The V-rule is a fundamental principle used to interpret the dip of rock layers from map patterns. When a dipping bed crosses a valley, the outcrop pattern forms a V-shape. According to this rule, the vertex of the V points in the direction that the bed is dipping, provided the dip angle is greater than the gradient of the valley.

23. (D) Changes in the dip and strike of rock layers
The primary evidence for recognizing folds in the field is the systematic change in the dip and strike of rock layers across an area. As layers are bent, their orientation changes relative to horizontal and north. By measuring these attitudes at multiple locations, geologists can reconstruct the geometry of the fold, identifying the positions of hinges, limbs, and the axial plane.

24. (A) Oldest
A dome is a structural feature where rock layers dip away from a central point in all directions, essentially forming an upward-pointing circular or elliptical fold. When erosion removes the top of the dome, the strata that were originally deepest and oldest are exposed at the center. Progressively younger rocks are found in concentric circles moving away from this central core.

25. (A) Both A and R are true and R is the correct explanation of A
Superimposed folding occurs when a rock sequence is subjected to multiple deformation events with different stress orientations. An existing fold structure can be refolded by a subsequent event, creating complex interference patterns. For example, if two sets of upright folds cross at right angles, they can produce a series of domes and basins, illustrating the history of changing tectonic forces.

26. (B) An isoclinal fold
An isoclinal fold is a specific type of fold where the two limbs are parallel to each other and also parallel to the axial plane. This indicates that the inter-limb angle is zero degrees. Such structures form under conditions of intense compression where the rock layers have been squeezed so tightly that the limbs can no longer be further compressed without fracturing.

27. (A) Axial trace
The axial trace is the line produced by the intersection of the axial plane of a fold with the surface of the Earth. On a geological map, this trace indicates the general orientation and position of the fold. It is distinct from the hinge line, which is the line of maximum curvature on a specific layer within the three-dimensional fold structure.

28. (D) Classification based on the rock's mineral composition
Folds are primarily classified based on their geometric and structural characteristics

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rather than their mineral content. Common classification schemes include the inter-limb angle, the attitude of the axial plane, and the symmetry of the limbs. While the mineral composition can influence the rock's ductility and how it folds, it is not a standard criterion for the formal classification of fold types.

29. (C) The stress conditions required for fracture or faulting
On a Mohr circle diagram, the failure envelope represents the boundary between stable stress states and those that cause the rock to fail. When the Mohr circle for a particular state of stress touches or intersects this envelope, it indicates that the shear stress on a plane has reached the rock's shear strength, resulting in the formation of a fracture or fault.

30. (B) P-3, Q-4, R-2, S-1
Plunging folds feature a hinge line inclined to the horizontal plane. Chevron folds are characterized by straight limbs and sharp hinges. Symmetrical folds have an essentially vertical axial plane that bisects the structure. Asymmetrical folds possess limbs of unequal length and dip angles. These geometric features are crucial for classifying fold types based on their symmetry and hinge characteristics.

31. (A) The rock block that lies above the fault plane
In structural geology, the hanging wall is the block of rock that resides physically above an inclined fault plane. This terminology originates from old mining practices where miners would hang their lanterns on the rock above them. Identifying the hanging wall and its movement relative to the footwall below is essential for determining whether a fault is normal, reverse, or thrust.

32. (B) In a normal fault, the hanging wall moves down relative to the footwall; in a reverse fault, it moves up
Normal and reverse faults are distinguished by the relative movement of the hanging wall. In a normal fault, which is caused by tensional stress, the hanging wall moves downward. In a reverse fault, caused by compressional stress, the hanging wall is pushed upward over the footwall. These movements reflect whether the crust is being extended or shortened in a particular tectonic region.

33. (C) Net slip
Net slip represents the total displacement vector along a fault plane, indicating both the direction and the actual distance that two points, originally adjacent, have moved apart. It is the most comprehensive measure of fault movement, combining both the horizontal and vertical components of slip. Determining the net slip is vital for accurately calculating the total strain accommodated by a fault.

34. (D) Normal fault
The omission or disappearance of a specific stratigraphic layer within a sequence is a classic indicator of a normal fault. As the hanging wall moves down relative to the footwall under tensional stress, certain layers can be displaced such that they are missing from a vertical section or a specific outcrop. This contrasts with thrust faults, which typically cause the repetition of strata.

35. (B) Heave
In the context of dip-slip faults, heave is the horizontal component of the displacement measured perpendicular to the strike of the fault. It represents how much the two blocks have moved apart or toward each other horizontally. Conversely, the throw is the vertical component of the displacement. Both measurements are necessary to fully describe the geometry of the movement along the fault.

36. (B) Thrust fault
A thrust fault is a specific type of reverse fault characterized by a low-angle fault plane, typically dipping less than 45 degrees. These faults are the primary mechanism for crustal shortening in mountain belts, where large sheets of rock are pushed over younger strata. The low angle allows for significant horizontal transport of rock masses, sometimes over distances of many kilometers.

37. (A) Both Statement I and Statement II are correct
Slickensides are polished surfaces with linear grooves or striations that form on a fault plane due to frictional movement, providing direct evidence of the slip direction. Fault breccia

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consists of coarse, angular rock fragments created by the mechanical breaking and grinding of rocks during faulting. Both features are important field indicators used by geologists to identify and analyze ancient fault zones.

38. (A) Strike-slip fault
A strike-slip fault is characterized by predominantly horizontal motion, where the rock blocks on either side of the fault plane slide past each other. This movement occurs parallel to the strike of the fault. These faults are often vertical or near-vertical and are produced by shear stresses within the crust. Famous examples include the San Andreas Fault in California and the Dead Sea Transform.

39. (C) Separation
Separation refers to the apparent offset of a geological marker, such as a bedding plane, when viewed in a specific two-dimensional cross-section or map view. It is important to distinguish separation from slip, which is the true three-dimensional displacement vector. Separation can be misleading because its magnitude and direction depend entirely on the orientation of the viewing plane relative to the fault.

40. (D) 1, 2 and 3
The type of fault that forms is determined by the dominant stress regime. Normal faults result from tensional stresses that extend the crust. Reverse and thrust faults are produced by compressional stresses that shorten the crust. Strike-slip faults are the product of shear stresses where blocks slide horizontally. All three statements correctly link the specific fault type to its underlying mechanical cause.

41. (D) Dextral fault
A dextral fault, also known as a right-lateral strike-slip fault, occurs when the block of rock on the opposite side of the fault moves to the observer's right. This sense of motion is independent of which side of the fault the observer is standing on. If the opposite block moves to the left, it is instead classified as a sinistral or left-lateral fault.

42. (B) A joint is a type of fracture across which there has been no appreciable movement
While both are types of fractures, the fundamental difference lies in the displacement. A joint is a fracture along which there has been no measurable or appreciable movement parallel to the fracture surface. In contrast, a fault is a fracture that shows clear evidence of relative displacement between the two blocks of rock. Joints are often found in systematic, parallel sets across large regions.

43. (C) Foliation
Foliation is a general term for any pervasive, planar fabric in a rock. In metamorphic rocks, it typically results from the parallel alignment of platy minerals like mica or elongate minerals like amphibole in response to tectonic stress. This fabric forms perpendicular to the direction of maximum shortening and is a key indicator of the deformation and metamorphic history of the rock.

44. (D) Axial plane lineation
Lineations are linear fabric elements within a rock. Common types include mineral lineations, intersection lineations formed by the crossing of two planes, and crenulation lineations from micro-folding. While axial planes are important planar features in folds, the term axial plane lineation is not a standard classification. Lineations usually lie within a foliation plane and indicate the direction of stretching or tectonic transport.

45. (A) Slaty cleavage
Slaty cleavage is a type of foliation found in low-grade metamorphic rocks like slate. It consists of closely spaced, parallel planes of weakness caused by the alignment of very fine-grained clay and mica minerals. This fabric allows the rock to be easily split into thin, flat sheets, a property known as fissility. It typically forms perpendicular to the direction of maximum tectonic compression.

46. (B) Tensional stress from cooling, unloading, or tectonic uplift
Joints primarily originate from tensional stresses that exceed the tensile strength of the rock. These stresses can be caused by the cooling and contraction of igneous rocks, the removal of overlying weight through erosion (unloading), or regional tectonic uplift. Because rocks are much weaker in tension than in compression, joints are very common and often form systematic patterns across extensive geological provinces.

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47. (D) L-tectonite
An L-tectonite is a rock whose fabric is dominated by linear elements, such as elongated mineral grains or stretched pebbles, with little to no planar foliation. This type of fabric indicates a state of strain dominated by one-dimensional stretching or constriction. The orientation of the lineation in an L-tectonite typically reveals the direction of tectonic transport or the long axis of the strain ellipsoid.

48. (A) Cleavage typically forms parallel or sub-parallel to the axial plane
In folded rocks, cleavage and other types of foliation typically develop parallel or sub-parallel to the axial plane of the folds. This relationship occurs because both the folds and the cleavage are produced by the same regional stress field, with the cleavage forming perpendicular to the direction of maximum shortening. This geometric consistency is a powerful tool for structural analysis in the field.

49. (C) Schistosity
Schistosity is a type of foliation characteristic of medium-to-high-grade metamorphic rocks. It is defined by the preferred orientation of relatively large, visible platy minerals, most commonly micas like biotite and muscovite. This alignment gives the rock a distinctly layered or planar appearance and often a shiny luster. Schistosity represents more intense metamorphic conditions and greater recrystallization than slaty cleavage or phyllitic fabrics.

50. (B) Stoping
Stoping is a mechanism of pluton emplacement where magma moves upward by breaking off blocks of the overlying country rock. These blocks, known as xenoliths, are denser than the magma and sink through it, effectively making room for the ascending magmatic body. This process allows magma to penetrate the crust without necessarily requiring large-scale tectonic extension or the forceful pushing aside of rocks.

51. (B) Layer-parallel compression causing instability and wave-like forms
Buckling is a mechanical process of folding that occurs when a competent rock layer is subjected to compression parallel to its layering. This compression causes the layer to become unstable and deform into a series of wave-like folds. The wavelength of the resulting folds is determined by the thickness and stiffness of the competent layer relative to the surrounding weaker material.

52. (B) Reverse fault
According to Anderson's theory, the type of faulting is determined by which principal stress is vertical. In a compressional tectonic regime where the maximum principal stress is horizontal and the minimum principal stress is vertical, reverse faults will form. This orientation allows the rock to move upward against gravity, which is the path of least resistance for accommodating the horizontal crustal shortening.

53. (B) Caldera formation and the collapse or resurgence of a central block
Ring dykes and cone sheets are distinctive igneous intrusions often found around volcanic centers. They are typically associated with the formation of calderas, where a central block of the crust collapses into an underlying magma chamber or is pushed upward by magmatic pressure. The resulting fractures provide pathways for magma to intrude, forming circular or conical bodies that reflect the local stress state.

54. (C) Diapirism
Diapirism is a mechanism of pluton emplacement where a buoyant, relatively low-density body of magma rises through the crust. As it ascends, it forcefully pushes aside and deforms the surrounding country rock to make space for itself. This process often results in the formation of concordant structures, such as folds and foliations in the country rock that wrap around the rising pluton.

55. (A) Both A and R are true and R is the correct explanation of A
Anderson's theory correctly identifies that the orientation of the three principal stresses determines the resulting fault type. Normal faults are specifically associated with tensional environments where the maximum principal stress is vertical, exerted by the weight of the overlying rock. This configuration allows the crust to extend horizontally as the hanging wall moves downward along the inclined fault plane.

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56. (B) Dykes dipping inwards towards a common center or focus
Cone sheets are thin, intrusive dykes that form a conical pattern in three dimensions, dipping inwards toward a common magmatic source at depth. They are produced when the upward pressure of magma in a central chamber creates tensional fractures in the overlying roof rock. Magma is then injected into these fractures, solidifying into a series of nested, inward-dipping igneous bodies.

57. (C) Disconformity
A disconformity is a type of unconformity where the sedimentary layers above and below the contact are parallel to each other. Despite this parallelism, there is a significant gap in the geological record representing a period of erosion or non-deposition. Recognizing a disconformity often requires identifying an irregular, channeled erosional surface or using fossil evidence to detect the missing time.

58. (D) The horizontal axis represents strain and the vertical is stress
Mohr's circle is a graphical method for representing the state of stress at a point. The horizontal axis represents normal stress, while the vertical axis represents shear stress. The circle's diameter is the difference between the maximum and minimum principal stresses, and its radius is the maximum shear stress. It is a tool for stress analysis, not for plotting strain against stress.

59. (C) Inclination of the fold
The inclination of a fold refers to the angle between its axial plane and a vertical plane. This measurement is important for the structural classification of folds. For example, an upright fold has a vertical axial plane and zero inclination, while an overturned or recumbent fold has a significantly inclined or horizontal axial plane, reflecting the intensity of the tectonic forces.

60. (A) P-3, Q-1, R-2, S-4
Normal faults are driven by tensional stress. Reverse faults and upright folds are both products of horizontal compression, which shortens and thickens the crust. Strike-slip faults result from shear stress where blocks slide past each other. These relationships between tectonic structures and stress regimes are fundamental to understanding the geodynamics of the Earth's lithosphere and the formation of various geological provinces.

61. (C) Truncation of bedding or other geological structures
A key field indicator for a fault is the abrupt truncation of rock layers, mineral veins, or other pre-existing geological structures. When one side of a fracture moves relative to the other, the original continuity of these features is broken. This juxtaposition of different rock units along a planar surface provides clear evidence that significant displacement has occurred across the fracture.

62. (B) $\sigma 2$ (intermediate)
In a strike-slip faulting regime, according to Anderson's theory, the intermediate principal stress is oriented vertically. The maximum and minimum principal stresses are both oriented horizontally. This stress configuration results in vertical fault planes where the movement is purely horizontal, allowing the crustal blocks to slide past one another without significant vertical displacement or changes in crustal thickness.

63. (A) Flexural slip
Flexural slip is a folding mechanism where displacement occurs along the interfaces between adjacent rock layers. This process is similar to what happens when you bend a thick book or a deck of cards, as the individual pages must slide over one another to accommodate the change in shape. This mechanism is common in well-bedded, competent sedimentary sequences during the folding process.

64. (C) Mineral lineation
A mineral lineation is a linear fabric formed by the preferred orientation of individual elongate mineral grains, such as hornblende or actinolite. This alignment typically occurs during deformation and metamorphism, as minerals grow or rotate to align with the direction of maximum stretching or tectonic transport. This feature is a valuable indicator of the kinematic history and strain orientation within the rock.

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65. (C) LS-tectonite
An LS-tectonite is a deformed rock that possesses both a well-developed planar fabric and a well-developed linear fabric. This means it has both a foliation and a lineation. Such fabrics are common in rocks that have undergone significant strain, where mineral grains have both flattened into planes and stretched into lines, reflecting a complex, three-dimensional state of tectonic deformation.

66. (B) Withdrawal of magma from a chamber causing the roof to collapse
Cauldron subsidence occurs when a large volume of magma is withdrawn from a chamber, often during a massive volcanic eruption. The loss of internal pressure causes the roof of the chamber to lose its support and collapse downward along circular or arcuate fractures. Magma can then rise through these fractures, solidifying to form ring dykes that encircle the subsided central block.

67. (A) Both Statement I and Statement II are correct
Progressive deformation describes the continuous evolution of rock structures during a single, uninterrupted tectonic event. In contrast, superimposed deformation occurs when a rock that has already been deformed is subjected to a completely separate, later deformational event with a different stress orientation. Distinguishing between these two processes is essential for accurately reconstructing the complex tectonic history of metamorphic terranes and mountain belts.

68. (A) Rock color
The mechanical behavior of a rock, whether it fractures as a brittle solid or flows as a ductile material, is controlled by physical and environmental factors. Key influences include the ambient temperature, the confining pressure from burial, the rate of strain, and the presence of fluids. However, the color of the rock is an optical property that has no effect on its mechanical strength.

69. (B) Open
Folds are often classified based on their inter-limb angle, which is the angle measured between the two limbs of the fold. An open fold has an inter-limb angle between 70 and 120 degrees. This classification indicates a moderate amount of deformation. Folds with larger angles are described as gentle, while those with smaller angles are classified as tight or even isoclinal.

70. (A) 1 and 2 only
Slip is the true displacement vector along a fault, while separation is the apparent offset of a marker seen in a particular view. These two measurements can differ significantly. Throw is defined as the vertical component of the displacement in a dip-slip fault, not the horizontal component. Therefore, the third statement is incorrect, while the first two are accurate structural definitions.

71. (B) Paraconformity
A paraconformity is a type of unconformity where there is a significant gap in the geological record, but the strata above and below are parallel and there is no obvious erosional surface. Because it looks like a normal, continuous sedimentary sequence, it is extremely difficult to recognize in the field. It usually requires detailed paleontological study to identify the missing time interval.

72. (B) Schistosity is defined by mineral grains large enough to be seen with the naked eye, while slaty cleavage is not
Slaty cleavage and schistosity are both types of foliation, but they represent different intensities of metamorphism. Slaty cleavage occurs at low grades and is defined by very fine-grained minerals that are invisible to the naked eye. Schistosity forms at higher grades where mineral grains, particularly micas, have grown large enough to be clearly visible, giving the rock a distinctly sparkly and coarser texture.

73. (C) The youngest rocks in the core, with progressively older rocks away from the center
A syncline is a downward-arching fold. In an upright, non-plunging syncline, the rock layers dip toward the central axial plane. Consequently, the youngest strata are preserved in the center or core of the fold. As you move outward from the axis onto the limbs, you encounter progressively older rock layers. This age pattern is a definitive feature used for mapping synclinal structures.

74. (C) Transform fault
A transform fault is a large-scale strike-slip fault that forms a plate boundary, allowing two

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tectonic plates to slide horizontally past each other. Unlike other strike-slip faults, transform faults connect different types of plate boundaries, such as two segments of an oceanic ridge. They accommodate the differential motion between plates and are major sites of seismic activity, like the San Andreas Fault.

75. (C) A step-like fold with a steeper zone in horizontal layers
A monocline is a simple, step-like fold in which otherwise horizontal or gently dipping rock layers are bent into a steeper inclination over a short distance. It typically has only one dipping limb connecting two horizontal sections. Monoclines are often produced by the movement of a fault in the underlying basement rocks that does not reach the surface but deforms the overlying sedimentary sequence.

76. (B) Infer the kinematics and orientation of the strain field
The symmetry of deformed rock fabrics and structures provides crucial information about the kinematic history and the orientation of the strain field during deformation. For example, orthorhombic symmetry suggests coaxial deformation, while monoclinic symmetry often indicates non-coaxial strain like simple shear. By analyzing these symmetry patterns, geologists can reconstruct the directions of movement and the overall tectonic environment of the region.

77. (C) Fold
Brittle deformation occurs when rocks break or fracture, resulting in structures such as faults and joints. Folds, however, are typically the result of ductile deformation, where rocks bend or flow without losing their internal cohesion. Folding usually occurs under conditions of high temperature and pressure, which allow the rock to behave like a plastic material rather than a brittle one.

78. (A) Eroded dome
A dome is a structural feature where rocks dip away from a central point in all directions. When a dome is eroded, it creates a map pattern of concentric, elliptical outcrops. Because the center was the highest point of the structure, the erosion exposes the oldest rocks in the middle, surrounded by progressively younger strata. This is the opposite of a basin pattern.

79. (C) Throw
In the study of faults, throw is defined as the vertical component of the net slip. It measures how much one block has been vertically displaced relative to the other. Heave is the corresponding horizontal component of the dip-slip. Both measurements are used to quantify the total movement on a fault and are particularly important in mining and petroleum geology for locating displaced layers.

80. (A) Both A and R are true and R is the correct explanation of A
Thrust faults are low-angle reverse faults that push older rock units up and over younger ones. When a borehole is drilled through such a sequence, it can pass through the same set of rock layers more than once—first in the hanging wall and then again in the footwall. This repetition of strata is a definitive indicator of thrusting in the subsurface.

81. (D) An intersection lineation
An intersection lineation is a linear feature formed where two planar structures in a rock meet. A very common example is the line formed by the intersection of sedimentary bedding and tectonic cleavage. In the field, this lineation is parallel to the hinge line of the associated folds. It is a vital tool for geologists to determine the orientation and plunge of larger fold structures.

82. (A) Concentric fold
A concentric fold, also known as a parallel fold, is characterized by layers that maintain a constant thickness throughout the structure. This results in rounded hinges and relatively straight limbs. To maintain this constant thickness, the shape of the fold must change from layer to layer, with the curvature typically becoming sharper toward the core of the fold. This style is common in competent rocks.

83. (C) Thrust Fault - Tensional stress
This is an incorrect pair because thrust faults are actually produced by compressional stress, not tensional stress. Tensional stress results in normal faults where the crust is pulled apart. Thrust faults are low-angle reverse faults that

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occur in environments where the crust is being squeezed and shortened. Compressional forces drive the hanging wall upward and over the footwall, reflecting a convergent tectonic setting.

84. (D) Creep
Creep is the slow, continuous, and non-recoverable deformation of a rock that occurs under constant stress over a long period. Unlike sudden brittle fracture or seismic slip, creep happens gradually. It is particularly important at high temperatures and pressures deep in the crust or mantle, where rocks can flow very slowly, effectively accommodating tectonic stresses without the immediate release of energy through earthquakes.

85. (A) 3, 1, 2, 4
According to the principles of cross-cutting relationships and superposition, the oldest event is the intrusion of the pluton into the schist. Next, the horizontal sandstone was deposited. These layers were then tilted and eroded, creating an unconformity surface. Finally, the horizontal conglomerate and shale were deposited on top. This sequence accurately reconstructs the regional geological history from oldest to most recent event.

86. (B) Increase in strain rate
Ductility is the ability of a rock to deform permanently without fracturing. Increasing the temperature or confining pressure generally enhances ductility by allowing internal processes like recrystallization to occur. However, increasing the strain rate—the speed at which the rock is deformed—tends to make the rock behave more brittly. When stressed rapidly, the rock does not have time to flow and instead breaks or fractures.

87. (C) The magnitudes and orientations of the two principal stresses are known
In two-dimensional stress analysis, the state of stress at any point can be fully described if you know the magnitudes and directions of the maximum and minimum principal stresses. With this information, you can use mathematical formulas or the Mohr circle diagram to calculate the normal and shear stress acting on any plane passing through that point, regardless of its specific orientation.

88. (D) Both were upright and they interfered at a high angle
A Type 1 interference pattern, characterized by a series of domes and basins, occurs when two sets of upright folds are superimposed at a high angle, typically near 90 degrees. The interference of the two sets of anticlines creates the domes, while the crossing of the two sets of synclines forms the basins. This pattern is a clear indicator of two distinct phases of compression.

89. (C) Oblique-slip fault
An oblique-slip fault is a fault that exhibits significant components of both horizontal movement and vertical movement. This means the total displacement vector, or net slip, is inclined relative to both the strike and the dip of the fault plane. Most natural faults have at least a small component of oblique motion, although they are often classified by their dominant sense of displacement.

90. (B) P-3, Q-1, R-4, S-2
Lineations are linear fabric elements, whereas foliations are planar fabrics within a rock. A joint is a fracture where there has been no measurable displacement, whereas a fault is a fracture that shows clear evidence of displacement. These definitions are fundamental to structural geology, allowing for the precise description and classification of the various features produced by the deformation of the Earth's crust.

91. (D) The bed is dipping less steeply than the valley gradient, in the same direction
According to the V-rule, if a bed dips in the same direction as the valley gradient but at a shallower angle, the outcrop pattern will form a V that points downstream. If the bed dips more steeply than the valley, the V points upstream. Understanding these geometric relationships is essential for geologists when interpreting map patterns and determining the underground orientation of rock layers.

92. (B) A strong, stiff layer that tends to buckle and control the fold wavelength
In the context of folding, competence refers to the relative strength and resistance of a rock layer to deformation. A competent layer is stiffer and stronger than the surrounding rocks. During compression, it tends to maintain its thickness

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and buckle, effectively controlling the overall wavelength and style of the resulting fold. Incompetent layers are weaker and typically accommodate deformation through flow or internal strain.

93. (C) A set of closely spaced, parallel planar surfaces induced by deformation
In structural geology, cleavage refers to the tendency of a rock to split along closely spaced, parallel planar surfaces that were created during tectonic deformation. This fabric is distinct from mineral cleavage and is usually developed in low-to-medium-grade metamorphic rocks. It forms perpendicular to the direction of maximum compression and is often associated with the formation of folds in the same regional stress field.

94. (D) Collapse of a central block along a fracture with magma filling it
Ring dykes are primarily formed during cauldron subsidence, where a large, circular or arcuate block of the Earth's crust collapses into an underlying magma chamber. This collapse occurs along vertical or steeply dipping fractures. As the central block sinks, magma is forced upward into these fractures, solidifying to form a circular or ring-shaped dyke that surrounds the subsided area of the crust.

95. (A) Both Statement I and Statement II are correct
The mechanical behavior of rocks is highly sensitive to environmental conditions. Increasing the rate of strain makes a rock more likely to fracture brittly, as it lacks the time for internal ductile processes to occur. Conversely, increasing the temperature provides mineral grains with the thermal energy needed for recrystallization and flow, which promotes ductile behavior. Both statements accurately describe these fundamental physical principles.

96. (B) Anticline
An anticline is a type of fold that is typically convex upward, meaning the rock layers are arched. The two limbs dip away from the central axial plane. Because of this upward arching, the oldest rocks in the stratigraphic sequence are located in the center or core of the fold. Synclines are the opposite, being concave upward with the youngest rocks in the core.

97. (C) Fault plane
The fault plane is the discrete surface or narrow zone across which displacement has occurred between two blocks of rock. It separates the hanging wall, which is the block located above the inclined plane, from the footwall below. The orientation of this surface, described by its strike and dip, is a primary characteristic used to classify and analyze the mechanics of faulting in the crust.

98. (A) Basal conglomerate
Fault zones are characterized by rocks produced by the grinding and deformation of the crust, such as fault breccia, gouge, and mylonite. These materials reflect the intense mechanical processes along the fault plane. However, a basal conglomerate is a sedimentary feature that typically marks an unconformity, representing the start of a new depositional sequence. It is not a product of the faulting process itself.

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99. (C) Diapirism
Diapirism is a mechanism of pluton emplacement where a body of low-density magma rises through the crust because it is more buoyant than the surrounding, denser country rock. This process is analogous to the movement of salt in salt domes. As the magmatic diapir ascends, it forcefully displaces and deforms the overlying rock, often creating distinctive concordant structures in the surrounding metamorphic terrane.

100. (C) 1 and 3 only
Slaty cleavage is indeed characteristic of low-grade metamorphic conditions, forming from the alignment of very fine minerals. Cleavage also typically forms perpendicular to the direction of maximum tectonic shortening. However, the second statement is incorrect because schistosity involves minerals like micas that have grown large enough to be clearly visible to the naked eye, unlike the microscopic grains found in slaty rocks.

101. (B) Deformation was purely coaxial (pure shear)
Orthorhombic symmetry in a deformed rock fabric implies that the deformation was coaxial, also known as pure shear. In this type of strain, the principal axes of the strain ellipsoid maintain the same orientation throughout the entire deformation process. This results in three

mutually perpendicular planes of symmetry, reflecting a systematic and balanced shortening and extension of the rock mass in response to stress.

102. (A) $\sigma 1 > \sigma 2 > \sigma 3$
In a general three-dimensional state of stress, there are three mutually perpendicular principal stresses. By convention, these are ordered by magnitude, where sigma-one is the maximum principal stress, sigma-two is the intermediate principal stress, and sigma-three is the minimum principal stress. The differences between these magnitudes determine the shear stresses acting within the rock and ultimately control whether the rock will fail.

103. (B) A significant gap in the fossil record across a contact
While physical features like basal conglomerates and angular discordance are important, the most definitive proof of an unconformity is a significant gap in the fossil record. This biostratigraphic evidence confirms that a period of time is missing, representing an interval of non-deposition or erosion. Such evidence can identify paraconformities and disconformities even when there is no obvious physical discordance between parallel rock layers.

104. (D) Chevron fold
A chevron fold is a specific structural style characterized by straight limbs and a very sharp, angular hinge. These folds typically form in sequences of thin, alternating layers of competent and incompetent rocks. The geometric regularity of chevron folds is produced as the layers bend sharply to accommodate compressional stress, creating a distinctive zigzag or saw-tooth pattern in cross-section or outcrop.

105. (C) Dome and basin structures
When a second set of upright folds is superimposed at a right angle on an existing set of upright folds, the resulting interference produces a dome and basin pattern. The domes form where the anticlines of both sets intersect, while the basins form at the intersection of the two sets of synclines. This complex outcrop pattern is a classic indicator of two distinct tectonic events.

106. (B) A small cliff or step created by fault movement at the surface
A fault scarp is a topographic feature consisting of a steep slope or small cliff produced when a fault displaces the Earth's surface. It represents the surface expression of the fault movement. Over time, erosion typically wears down the scarp, but fresh scarps provide direct evidence of recent seismic activity and the direction of displacement along the underlying fault plane in the crust.

107. (C) Separation is the apparent offset seen in a 2D view, while slip is the true 3D displacement vector
Slip and separation are distinct concepts in fault analysis. Slip is the actual, three-dimensional displacement vector between two points that were originally together. Separation is merely the apparent offset of a geological feature, like a bed or a vein, as seen on a specific map or cross-section. Understanding the difference is crucial because separation can be very different from the true magnitude and direction of slip.

108. (A) A regional stress field during tectonic events
Systematic joints are characterized by their consistent orientation and spacing over large areas. They typically form in sets in response to a regional stress field, often associated with tectonic events such as crustal extension or uplift. The uniformity of these joints across different rock types and locations indicates that they are produced by broad, large-scale forces rather than localized weathering or random processes.

109. (C) A lineation can be a fabric element that lies within a foliation plane
Foliation and lineation are often related fabric elements in deformed rocks. Foliation is a planar fabric, while lineation is a linear one. In many metamorphic rocks, such as schists, linear elements like stretched mineral grains or the intersection of two planes often lie directly within the foliation plane. This relationship reflects the three-dimensional nature of the strain that the rock experienced during its tectonic history.

110. (A) Both A and R are true and R is the correct explanation of A
Cone sheets are intrusive bodies that dip inward toward a central point, forming a nested conical

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structure. They result from the upward pressure of a central magma body, which generates conical tensional fractures in the overlying rock. Magma is then injected into these fractures, which naturally converge at depth toward the magma source, making both the assertion and the reason scientifically correct.

111. (D) Symmetrical and upright
A fold with a vertical axial plane that divides the structure into two mirror-image halves is classified as symmetrical and upright. In this case, the limbs dip at the same angle but in opposite directions. This geometry indicates that the compressional forces were balanced and horizontal, leading to a perfectly symmetrical shortening of the rock layers around a vertical plane of symmetry.

112. (B) Gneissic banding
Gneissic banding is a high-grade metamorphic foliation characterized by the segregation of minerals into distinct light and dark layers. The light-colored bands are typically rich in felsic minerals like quartz and feldspar, while the dark bands contain mafic minerals like biotite and hornblende. This prominent compositional layering forms through intense pressure and temperature, which allow for the chemical migration and recrystallization of minerals.

113. (C) It is perpendicular to the slip direction and lies within the fault plane
Anderson's theory states that faulting occurs on planes of maximum shear stress. In any faulting regime, the intermediate principal stress is oriented within the fault plane itself. Crucially, it is also oriented perpendicular to the direction of slip. This geometric relationship is a fundamental part of the stress analysis used to explain why different orientations of principal stresses produce normal, reverse, or strike-slip faults.

114. (D) The geographic location on Earth's surface
The mechanical behavior of a rock depends on the environmental and physical conditions it experiences, such as temperature, pressure, strain rate, and fluid pressure. These factors determine whether the rock will deform elastically, plastically, or through brittle fracture. However, the specific geographic location on the surface has no inherent influence on how the rock material responds to stress at a fundamental physical level.

115. (A) Normal fault
A normal fault is a type of dip-slip fault where the hanging wall moves downward relative to the footwall. These faults are typically produced by tensional stresses that act to pull the Earth's crust apart, leading to crustal extension. Normal faults are common in tectonic settings such as continental rifts and mid-ocean ridges where the lithosphere is being stretched and thinned.

116. (C) Sedimentary rocks deposited on top of an eroded surface of older crystalline (igneous or metamorphic) rocks
A nonconformity is a specific type of unconformity where younger sedimentary layers are deposited directly onto an eroded surface of older crystalline rocks, which can be either igneous or metamorphic. This contact represents a vast gap in time, as the older rocks had to be formed at depth, uplifted to the surface, and eroded before the new sedimentary deposition could begin.

117. (D) The difference between the maximum and minimum principal stresses ($\sigma 1 - \sigma 3$)
In a Mohr circle diagram, the diameter of the circle is the horizontal distance between the two points representing the maximum principal stress and the minimum principal stress. This value is known as the differential stress. It is a critical parameter in structural geology because the magnitude of this difference determines the size of the circle and thus how close the stress state is to the failure envelope.

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118. (B) Plunging
A fold is described as plunging when its hinge line is not horizontal but instead makes an angle with the horizontal plane. This angle is called the plunge. Plunging folds create distinctive outcrop patterns on geological maps, such as V-shapes or U-shapes that close or open in the direction of the plunge. Most natural folds exhibit some degree of plunge rather than being perfectly horizontal.

119. (B) Reverse or thrust fault
The repetition of a specific stratigraphic sequence within a vertical drill core is a hallmark of reverse or thrust faulting. Because these faults push older

rocks up and over younger ones along an inclined plane, a vertical borehole will pass through the same layers twice—first in the hanging wall and then again in the underlying footwall. This repetition is used to identify and map faults.

120. (A) P-3, Q-1, R-4, S-2
In fold terminology, the hinge is the line of maximum curvature, and the limbs are the sides of the fold. The axial plane is the surface that connects the hinges of all layers, while the plunge is the angle that the fold axis makes with the horizontal. These terms provide a complete geometric description of a fold structure, essential for mapping and tectonic interpretation.

121. (C) Tensional joint
Radial fractures often form around an uplifting dome or a central magmatic intrusion due to the outward and upward stretching of the overlying rock. These are a type of tensional joint, created as the rock's tensile strength is exceeded by the expansive forces. Such joint patterns are important indicators of localized uplift and provide pathways for fluid migration or subsequent mineral deposition in the crust.

122. (A) S-tectonite
An S-tectonite is a rock characterized by a dominant planar fabric, or foliation, with little to no visible linear fabric. The S" stands for schistosity or surfaces. This type of fabric is produced by a state of strain where the rock has been flattened significantly in one direction, causing mineral grains to align into parallel planes, but has not undergone significant one-dimensional stretching.

123. (C) Concordant folding and foliation parallel to the pluton margin
Forceful injection is a mechanism of pluton emplacement where magma actively pushes aside and deforms the surrounding country rock. This process typically results in the formation of structures that are concordant with the pluton's margins. Common features include folds and a metamorphic foliation in the country rock that wrap around the magmatic body, reflecting the intense localized strain caused by the rising, expanding magma.

124. (D) A sinistral fault
A sinistral fault, also called a left-lateral strike-slip fault, occurs when the block of rock on the far side of the fault moves to the observer's left. This sense of horizontal displacement is a fundamental characteristic used to classify strike-slip faults. Sinistral motion reflects a specific orientation of the regional shear stresses acting on the crustal rocks in that particular tectonic setting.

125. (C) Recognizing folds and determining the direction of dip of strata from map patterns
The rule of Vs is a geometric principle used to interpret the dip direction of rock layers where they cross topographic features like stream valleys. On a geological map, the outcrop of a dipping bed will form a V-shape. By observing whether the V points upstream or downstream relative to the topography, geologists can determine the direction and relative steepness of the layer's dip.

126. (C) Statement I is incorrect, but Statement II is correct
Brittle deformation is actually favored by low confining pressure and low temperatures, which allow rocks to fracture. High confining pressure, on the other hand, inhibits fracturing and promotes ductile behavior. High temperatures also promote ductility by providing energy for internal flow and recrystallization. Therefore, only the second statement is correct, as it accurately reflects how environmental conditions influence a rock's mechanical response to stress.

127. (D) The orientation of the second fold set is always parallel to the first
Superimposed folding occurs when a rock sequence is subjected to multiple, distinct phases of deformation. This often results in complex outcrop patterns, such as domes and basins, and can be recognized by the presence of refolded folds. However, the second set of folds is rarely parallel to the first; instead, it typically forms at a significant angle, reflecting a change in the regional stress orientation.

128. (A) Normal fault
The omission of strata is a characteristic feature of normal faults in a stratigraphic section. As the hanging wall moves down relative to the footwall,

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portions of the rock sequence are displaced such that certain layers may be missing when viewed vertically, such as in a cliff face or a drill core. This contrasts with reverse and thrust faults, which typically result in the repetition of strata.

129. (C) Crenulation
A crenulation is a set of small-scale, closely spaced micro-folds that develop when a pre-existing foliation, like slaty cleavage or schistosity, is deformed by a later phase of compression. These micro-folds create a new, secondary foliation known as crenulation cleavage. This feature is a clear indicator of multiple deformational events and is common in complex metamorphic terranes that have experienced polyphase tectonism.

130. (A) 1 and 2 only
Stoping involves magma breaking off and displacing blocks of country rock, while diapirism is the buoyant rise of magma through the crust. Both are recognized mechanisms of pluton emplacement. However, forceful injection is an active process where magma pushes aside and deforms the surrounding rock, not a passive one. Therefore, only the first two statements accurately describe the physical mechanics involved in these specific processes.

131. (A) The most general, non-symmetrical strain (general shear)
A triclinic strain pattern represents the most complex and least symmetrical form of deformation, occurring during general shear. In this state, there are no planes of symmetry within the resulting rock fabric. This reflects a non-coaxial deformation where the principal axes of strain rotate during the process, and the shortening and extension are not balanced by any mirror-image symmetry, common in complex tectonic zones.

132. (B) Overturned
A fold is classified as overturned when its axial plane is inclined and both limbs dip in the same direction. This indicates that one of the limbs has been rotated past the vertical position, meaning it is stratigraphically upside down. Overturned folds are common in regions of intense crustal shortening and provide important evidence for the direction and magnitude of tectonic transport in mountain belts.

133. (C) Upward-directed magmatic pressure from a central intrusion
Cone sheets are thin, inward-dipping igneous intrusions that form a conical pattern. They are produced by the upward pressure of magma within a central chamber, which creates a series of conical tensional fractures in the overlying rock. Magma is then forcefully injected into these fractures. This process is a direct result of localized magmatic forces rather than broader regional tectonic extension or compression.

134. (D) Joint
A joint is a type of fracture in a rock across which there has been no measurable or significant displacement parallel to the fracture surface. While joints are common in all rock types and often occur in systematic sets, they differ from faults because they lack the relative movement of the rock blocks. They are primarily the result of tensional stresses exceed the rock's tensile strength.

135. (A) A rock body undergoes continuous change in shape and orientation during a single tectonic event
Progressive deformation describes a single, continuous tectonic process where rock layers are gradually and systematically deformed over time. During this event, the shape, size, and orientation of structures like folds and foliations evolve as strain accumulates. This concept allows geologists to understand complex geometries as the result of a steady, ongoing process rather than requiring many separate and unrelated episodes of deformation.

136. (B) The accumulation of stress to the point where it exceeds the rock's strength
Faulting is the fundamental result of rocks reaching their breaking point under tectonic pressure. As stress accumulates in the crust due to plate movements, the rock eventually reaches its maximum strength. When the applied stress exceeds this limit, the rock fractures and displacement occurs along a fault plane, releasing the stored energy as an earthquake and resulting in permanent crustal deformation.

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137. (A) The orientation of slickensides or mineral-fiber lineations
Slickensides and mineral-fiber lineations are direct indicators of the direction of movement on a fault plane. Slickensides are polished surfaces with grooves or striations formed by friction, while mineral fibers grow in the direction of slip as the fault moves. By measuring the orientation of these linear features, geologists can accurately determine the specific kinematic path that the rock blocks took during faulting.

138. (A) Away from the nose, in the core of the fold
In a plunging anticline, the rock layers are arched upward and the entire structure is tilted. After erosion, the oldest rocks are exposed in the central core of the fold. Specifically, these oldest strata appear furthest away from the nose" of the fold, which is the point where the outcrop pattern V's or closes in the direction of the plunge.

139. (D) Isoclinal
An isoclinal fold is characterized by having limbs that are parallel or nearly parallel to each other. This means the inter-limb angle is extremely small, typically between 0 and 10 degrees. Isoclinal folds reflect a high degree of crustal shortening and intense deformation, where the rock layers have been squeezed so tightly that the limbs can no longer be compressed further without fracturing.

140. (A) 4, 1, 3, 2
An orogenic cycle typically begins with the deposition of sediments in a basin. Intense tectonic forces then cause the formation of recumbent folds and thrust faults. This is often followed by a later stage of compression that produces upright, open folds. Finally, the cycle ends with the uplift and erosion of the mountain belt, followed by the deposition of new, post-orogenic sediments.

141. (B) Pitch or Rake
The pitch, also known as the rake, is the angle between a linear feature, such as a lineation, and the horizontal line within the plane where that feature lies. It is measured within the foliation or fault plane. This measurement is distinct from the plunge, which is the angle between the lineation and the horizontal plane measured in a vertical plane.

142. (A) Simple shear
Monoclinic symmetry is a characteristic feature of simple shear, which is a non-coaxial type of deformation. In simple shear, the rock undergoes a change in shape by sliding along parallel planes, similar to a deck of cards being pushed to one side. This process results in a single plane of symmetry in the resulting strain ellipsoid and rock fabric, reflecting the directional nature of the movement.

143. (D) A gradual, conformable transition between two rock types indicates an unconformity
This statement is incorrect because a gradual, conformable transition actually indicates continuous deposition without a significant time gap. In contrast, an unconformity is marked by signs of a break in the record, such as an angular discordance, an erosional surface, a basal conglomerate, or specific biological indicators like burrows that are filled with sediment from the younger, overlying rock layer.

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144. (A) It forms a U" shape that opens in the direction of plunge
A plunging syncline is a downward-arching fold with an inclined hinge line. On a geological map, its outcrop pattern typically forms a U-shape or V-shape. For a syncline, this pattern opens in the direction of the plunge. This is the opposite of a plunging anticline, where the outcrop pattern closes or V's in the direction of the plunge. These patterns are essential for structural mapping.

145. (A) Both A and R are true and R is the correct explanation of A
Joints are fractures that significantly increase the surface area of a rock mass exposed to the environment. They also act as primary pathways for the movement of fluids like groundwater or hydrothermal solutions. This increased permeability and surface area directly lead to enhanced chemical weathering and provide sites for the deposition of minerals, making both the assertion and the reason accurate and logically linked.

146. (B) Strike slip
Strike slip is the horizontal component of the net displacement along a fault plane, measured parallel to the strike of the fault. It describes how much the two blocks of rock have moved past

each other horizontally. This is distinct from the dip slip, which is the movement parallel to the dip direction, and the heave, which is the horizontal component of dip-slip.

147. (C) A crenulation lineation
A crenulation lineation is a linear feature produced by the small-scale folding, or crenulation, of a pre-existing foliation. These micro-folds create a series of parallel ridges and grooves on the foliation surface. This type of lineation is a clear indicator of at least two phases of deformation, where the second phase has compressed and folded the planar fabric created during the first phase.

148. (A) Gradual accumulation of strain until rock strength is overcome by stress
Faulting occurs because of the steady buildup of tectonic stress within the Earth's crust. As rocks are pushed or pulled by plate movements, they accumulate strain elastically. Eventually, the applied stress exceeds the rock's shear strength. At this point, the rock fails brittly, resulting in a fracture and sudden displacement along a fault plane, which releases the stored strain energy.

149. (C) Passive flow folding
Passive flow folding occurs in weak, incompetent layers that lack the mechanical strength to buckle on their own. Instead, they are squeezed and flow like a viscous fluid between stronger, competent layers that are undergoing folding. This results in the incompetent material thickening in the fold hinges and thinning along the limbs, creating a fold style where the layering does not control the deformation.

150. (B) P-3, Q-1, R-2, S-4
Normal faults form in tensional regimes where the maximum principal stress is vertical. Reverse faults result from horizontal compression with a vertical minimum stress. Strike-slip faults occur when the intermediate stress is vertical. Thrust faults are a specific type of low-angle reverse fault produced by intense horizontal compression. These stress orientations are the fundamental physical controls on the different types of faulting observed.

151. (A) Applied stress exceeds rock strength under specific conditions
The fundamental mechanical principle behind rock failure is that it occurs whenever the applied tectonic stress exceeds the internal strength of the rock. This strength depends on factors like the rock type, temperature, and confining pressure. When the stress reaches this critical threshold, the rock can no longer accommodate the strain elastically and instead fails through either brittle fracturing or ductile flow.

152. (A) A triaxial ellipsoid
In three-dimensional strain analysis, if all three principal axes of the strain ellipsoid have different lengths (X, Y, and Z), the resulting shape is a triaxial ellipsoid. This represents a general state of strain where the rock has been stretched in one direction and shortened in another, with the third direction experiencing an intermediate amount of change. This is the most general case of deformation.

153. (B) An erosional surface separating parallel strata
A disconformity is recognized as an erosional surface that separates two parallel sets of sedimentary strata. Despite the lack of angular discordance, a significant gap in time exists between the layers. Field evidence for a disconformity can include an irregular, channeled contact, a basal conglomerate, or the presence of soil horizons (paleosols) that indicate the surface was exposed to weathering before burial.

154. (B) Box fold
A box fold is a distinctive type of fold characterized by two separate hinges and a relatively flat crest or trough. This results in a cross-sectional shape that resembles a rectangle or a box. Box folds typically form in well-bedded sequences where the layers are relatively competent. They often occur in pairs and represent a style of folding where the deformation is distributed across two parallel axial surfaces.

155. (A) Both Statement I and Statement II are correct
Asymmetrical folds are defined by having limbs of unequal length, which gives the fold a non-mirror-image appearance. This geometric asymmetry is almost always accompanied by an inclined axial plane. These features result from a non-uniform application of tectonic stress

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or a component of shear, indicating that the compressional forces were not perfectly balanced or horizontal during the formation of the fold structure.

156. (C) Normal fault
The omission or disappearance" of a stratigraphic layer is a classic indicator of a normal fault. In this type of faulting, the hanging wall moves downward relative to the footwall under tensional stress. Consequently, certain layers in the sequence can be displaced such that they are missing from a vertical section, such as a cliff face or a borehole, providing a clear sign of crustal extension.

157. (D) They are primarily caused by tensional stress
This statement is incorrect because strike-slip faults are primarily caused by shear stress, not tensional stress. Tensional stress results in normal faults where the crust is pulled apart. Strike-slip faults involve blocks of rock sliding horizontally past each other, parallel to the strike of the fault. A dextral fault is right-lateral, and a sinistral fault is left-lateral, both reflecting different directions of regional shear.

158. (D) Columnar jointing
Foliation is a general term for any pervasive planar fabric in a rock, including slaty cleavage, schistosity, and gneissic banding, which result from the alignment of mineral grains during deformation. Columnar jointing, however, is a primary structure formed by the cooling and contraction of igneous rocks, creating a set of parallel, prismatic fractures. It is not a tectonic foliation produced by mineral alignment.

159. (B) Cleavage tends to form perpendicular to the maximum principal stress axis ($\sigma 1$), in the XY plane of the strain ellipsoid
Tectonic cleavage and other types of foliation develop in response to the regional stress field. As the rock is compressed, mineral grains rotate or recrystallize to align themselves in the direction of least resistance. This results in a planar fabric that forms perpendicular to the maximum principal stress and parallel to the plane of maximum extension (the XY plane) of the strain ellipsoid.

160. (B) 2 and 3 only
Cone sheets are formed by the injection of magma into inward-dipping conical fractures created by upward pressure. Cauldron subsidence is the primary mechanism for the formation of ring dykes, which occur when a central block collapses along arcuate fractures. However, ring dykes typically form in vertical or steeply dipping fractures, not necessarily outward-dipping ones. Thus, only the second and third statements are accurately described.

161. (A) In a sequence of alternating competent and incompetent layers subjected to layer-parallel compression
Buckling is a mechanical process of folding that is most effective when a sequence of rocks with different stiffnesses—such as alternating sandstone and shale layers—is compressed parallel to the layering. The stiffer, competent layers resist the compression and buckle into wave-like forms, while the weaker, incompetent layers flow to accommodate the change in shape. This is the primary mechanism for many mountain-belt folds.

162. (C) Both a planar and a linear fabric
An LS-tectonite is a deformed rock that displays both a well-developed planar fabric (foliation) and a well-developed linear fabric (lineation). This combined fabric indicates a state of strain where the rock has been both flattened into planes and stretched into lines. LS-tectonites are very common in high-strain zones like shear zones, where they reflect a complex, three-dimensional tectonic history and movement.

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163. (B) Forceful injection (diapirism)
Forceful injection, or diapirism, involves a buoyant magma body actively pushing aside and deforming the surrounding country rock as it rises. Evidence for this mechanism includes intense folding in the country rock and the development of a foliation that runs parallel to the margin of the pluton. These concordant structures indicate that the magma was an active agent of strain rather than passively filling space.

164. (B) A single point on the normal stress axis
Hydrostatic pressure, also known as lithostatic or confining pressure, occurs when the stress is equal in all directions (sigma-one = sigma-two =

sigma-three). On a Mohr circle diagram, because the difference between the principal stresses is zero, the diameter of the circle is zero. Therefore, the entire state of stress is represented by a single point located on the horizontal normal stress axis.

165. (A) Linear and parallel to the fold axis
For non-plunging folds, the outcrop pattern on a perfectly flat surface consists of a series of parallel bands of rock. These bands are oriented parallel to the hinge line or fold axis. Depending on whether the structure is an anticline or a syncline, the age of the rocks will either get older or younger toward the central axis, creating a symmetrical repetition of strata.

166. (C) Normal faults
Continental rift zones are regions where the lithosphere is being actively pulled apart by tensional stresses. This crustal extension is primarily accommodated by the formation of normal faults. Large-scale movement on these faults creates down-dropped blocks called grabens, which form the central rift valley, and uplifted blocks called horsts. The East African Rift is a classic modern example of this tectonic process.

167. (C) Nonconformity - Sedimentary rocks on crystalline rocks
A nonconformity is correctly identified as an unconformity where younger sedimentary rocks have been deposited on the eroded surface of older crystalline (igneous or metamorphic) rocks. Anticlines have the oldest rocks in the core, synclines have the youngest, and disconformities feature parallel beds rather than an angular relationship. Therefore, only the pair describing a nonconformity is a correct geological definition of these structural terms.

168. (C) Separation is an apparent offset in a 2D view and can be misleading about the true nature and magnitude of fault movement (slip)
Distinguishing between slip and separation is fundamental in structural geology. Slip is the actual, three-dimensional displacement between two originally adjacent points on a fault. Separation is merely the apparent offset of a marker feature, like a bed, as seen in a two-dimensional map or cross-section. Because separation depends on the orientation of the viewing plane, it can provide a very misleading estimate of fault movement.

169. (A) It involves the folding of an earlier-formed fold or foliation
A superimposed fold is a structure that forms when a new set of folds is imposed upon a rock that has already been deformed. This process results in the folding of earlier-formed foliations, lineations, or even entire fold structures. It is a hallmark of polyphase deformation in metamorphic terranes, where multiple tectonic events with different stress orientations have left their cumulative mark on the rock.

170. (C) Graded bedding
Graded bedding is a primary sedimentary structure where the grain size within a single bed systematically changes from coarse at the base to fine at the top. This feature is an excellent way-up" or top-direction" indicator. In complexly folded or overturned strata, geologists use graded bedding to determine which way was originally upward, helping to decipher the true geometry and history of the structure.

171. (A) Any linear, directional fabric element in a rock
Lineation is a broad term that encompasses any linear or directional feature within a rock fabric. This can include the alignment of elongated mineral grains, the intersection of two planar surfaces, grooves on a fault plane, or the long axes of stretched pebbles in a conglomerate. Lineations are essential tools for reconstructing the direction of tectonic transport and the orientation of the strain ellipsoid.

172. (A) Stoping
Stoping is a mechanism of pluton emplacement where magma moves upward by fracturing the overlying country rock. Blocks of this rock, called xenoliths, break off and sink into the magma, making room for the pluton. The presence of numerous angular fragments of the wall rock suspended in the granite near its margin provides strong physical evidence that this specific passive mechanism was active during the intrusion.

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173. (B) Reverse and thrust faults
In a tectonic setting dominated by horizontal compression, such as a continental collision zone, the maximum principal stress is horizontal. According to Anderson's theory, this stress regime primarily produces reverse and thrust faults. These structures allow the crust to shorten and thicken as rock masses are pushed upward and over each other, accommodating the intense convergent forces between the colliding lithospheric plates.

174. (D) Axial plane is horizontal or near-horizontal
A fold is classified as recumbent when its axial plane has been rotated into a horizontal or near-horizontal position. This indicates extreme deformation and significant horizontal transport of rock masses. In a recumbent fold, the limbs are also horizontal, and one limb is completely overturned, representing the most advanced stage of folding before the structure might transition into a large-scale thrust sheet or nappe.

175. (A) Both A and R are true and R is the correct explanation of A
A nonconformity is a major unconformity that represents a vast amount of missing geologic time. For it to form, deep-seated crystalline rocks must first be formed at great depth, then uplifted through the entire crust, and finally eroded to create a surface at the Earth's exterior. Only then can younger sedimentary rocks be deposited on top. This sequence of events accounts for the significant temporal gap.

176. (D) High temperature
Ductile deformation, where rocks flow or bend without fracturing, is strongly promoted by high temperatures. Increased thermal energy allows mineral grains to undergo processes like recrystallization and intracrystalline slip more easily. Conversely, low temperatures, low confining pressures, and high strain rates all favor brittle failure. Therefore, as rocks are buried deeper and become hotter, they transition from a brittle state to a more ductile one.

177. (B) A large-scale thrust fault
A window, or fenster, is an erosional hole in a large-scale thrust sheet (nappe) that exposes the younger footwall rocks underneath. This feature is a powerful tool for structural geologists because it allows them to see the rocks that were overridden by the thrust. The presence of a window proves that the older rocks in the thrust sheet are part of a displaced, allochthonous mass.

178. (B) Inter-limb angle
The inter-limb angle is the primary criterion used to classify folds based on the tightness of their limbs. This angle is measured between the two limbs of the fold. Folds are classified as gentle if the angle is 120–180 degrees, open if 70–120, tight if 10–70, and isoclinal if the limbs are parallel (0–10 degrees). This measurement provides a quantitative way to describe the intensity of deformation.

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179. (C) Foliation
Foliation is the general term for any pervasive, planar fabric in a rock. In metamorphic rocks, it is commonly created by the parallel alignment of platy minerals like mica or chlorite in response to tectonic stress. This fabric forms perpendicular to the direction of maximum shortening and is a fundamental characteristic of rocks like slate, phyllite, and schist, reflecting their deformation and metamorphic history.

180. (A) P-4, Q-2, R-1, S-3
Repetition of strata is a hallmark of thrust faults, while omission indicates normal faults. An angular discordance between sedimentary units defines an angular unconformity. Sedimentary rocks deposited on an eroded surface of granite create a nonconformity. These relationships are fundamental for interpreting subsurface data and field observations to reconstruct the structural and depositional history of a region's crustal layers and tectonic events.

181. (A) Shear and normal stress conditions required to fracture a rock
The failure envelope on a Mohr diagram is a boundary that separates stable stress states from those that lead to rock failure. It represents the combination of shear and normal stresses at which a rock will undergo brittle fracture. If a Mohr circle representing a specific stress state touches this envelope, the rock is predicted to fail by fracturing or faulting along a plane of maximum shear.

182. (D) Inclined and asymmetrical
A fold is described as inclined if its axial plane is not vertical. If the limbs dip in opposite directions at different angles and have unequal lengths, the fold is also asymmetrical. This geometry indicates that the tectonic forces were neither perfectly balanced nor vertical, often resulting from a combination of compression and a component of shear stress during the folding process.

183. (C) Statement I is correct, but Statement II is incorrect
Ring dykes are indeed circular or arcuate in plan view, representing vertical or steeply dipping intrusions. However, the second statement is incorrect because ring dykes form from magma filling the fractures created by cauldron subsidence, which are typically vertical to steeply outward-dipping. Cone sheets are the structures that specifically form from inward-dipping conical fractures. This distinction is crucial for understanding the different stress patterns around magmatic centers.

184. (D) The presence or absence of measurable displacement across the fracture
The fundamental distinction between a joint and a fault is the amount of displacement. A joint is a fracture along which there has been no measurable or significant movement parallel to the fracture surface. In contrast, a fault is a fracture that shows clear evidence of relative movement between the two blocks of rock. Both are types of brittle failure, but their structural significance differs greatly.

185. (A) Bending a deck of playing cards
Flexural slip is a folding mechanism where individual rock layers slide past each other to accommodate the bending of the overall structure. This is perfectly analogous to what happens when you bend a deck of playing cards or a thick book; the individual pages must slip relative to one another to allow the whole stack to curve without distorting the shape of the pages themselves.

186. (C) Conformity
An unconformity is a surface representing a gap in the geological record. Recognized types include disconformities, nonconformities, paraconformities, and angular unconformities. However, a conformity is the opposite of an unconformity; it represents continuous, uninterrupted deposition of sedimentary layers over time without a significant break or erosional event. Therefore, conformity is not a type of unconformity, but rather a description of a complete record.

187. (A) Normal faults and grabens
In a region of active crustal extension, the Earth's crust is being pulled apart by tensional stresses. This process is primarily accommodated by the development of normal faults. Large-scale extension often leads to a series of parallel normal faults that create down-dropped blocks called grabens and uplifted blocks called horsts, forming a characteristic rift-valley topography seen in places like the Basin and Range province.

188. (A) Lineation
A lineation is any linear or directional fabric element within a rock. Unlike foliations, which are planar, lineations are one-dimensional features. They can be formed by the alignment of elongate minerals, the intersection of two planar surfaces, or the stretching of objects like pebbles. Lineations are critical for determining the direction of tectonic transport and the orientation of the principal axes of the strain ellipsoid.

189. (A) An anticline that plunges in all directions away from a central point
A dome is a structural feature that can be thought of as a circular or elliptical anticline. The rock layers dip away from a central high point in all directions. Consequently, if the hinge lines were traced, they would plunge outward from the center. Erosion of a dome exposes the oldest rocks in the center, surrounded by concentric rings of progressively younger strata.

190. (D) 1, 2 and 3
All three statements correctly define fundamental structural features. A fault is a fracture with significant displacement, while a joint is a fracture where no measurable movement has occurred. A foliation is a pervasive planar fabric, common in metamorphic rocks, resulting from the tectonic alignment of mineral grains. Together, these terms provide the basic vocabulary for describing how the Earth's crust deforms and develops new textures.

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191. (C) Anderson's theory of faulting
Anderson's theory of faulting is a fundamental principle in structural geology that relates the type of fault to the orientation of the three principal stresses. It states that one of the principal stresses must be vertical at the Earth's surface. Depending on whether sigma-one, sigma-two, or sigma-three is the vertical stress, the resulting structure will be a normal, strike-slip, or reverse fault.

192. (C) Thrust sheet (nappe)
A klippe is an isolated, erosional remnant of a larger thrust sheet, or nappe, that has been separated from the main body of the thrust mass. It consists of older rocks that have been pushed over younger rocks and then left behind after the surrounding material was eroded away. The presence of a klippe is strong evidence for large-scale horizontal transport and complex tectonic deformation.

193. (C) A tensor quantity
In physics and geology, stress is a tensor quantity. Unlike a scalar, which has only magnitude, or a vector, which has magnitude and one direction, a tensor is required to describe how forces act in multiple directions simultaneously at a single point. A stress tensor fully accounts for the normal and shear stresses acting on all possible planes passing through that point in three-dimensional space.

194. (A) Younger than the sedimentary layers
The principle of cross-cutting relationships states that any geological feature that cuts across another must be the younger of the two. In this scenario, because the igneous dyke cuts through the pre-existing sedimentary layers, the dyke must have intruded and solidified after those layers were deposited and lithified. This fundamental rule is essential for determining the relative timing of events in geological history.

195. (B) Plunge
The plunge is the angle between a fold's hinge line and a horizontal plane, measured within a vertical plane. It describes how much the fold is tilted into the Earth. Folds with a plunge of zero are described as non-plunging or horizontal. The orientation and degree of plunge are critical for accurately mapping the three-dimensional geometry of fold structures and interpreting regional tectonic forces.

196. (A) Youngest
A basin is a structural feature where rock layers are bowed downward, essentially forming a circular or elliptical syncline. The strata dip toward a central point from all directions. When erosion levels the surface of a basin, the youngest rocks in the stratigraphic sequence are exposed at the center. Progressively older rocks are encountered in concentric patterns as you move outward toward the basin's edges.

197. (D) Subduction
Pluton emplacement refers to the specific mechanisms by which magma bodies move into and occupy space within the crust, such as stoping, diapirism, and forceful injection. Subduction, however, is a large-scale plate tectonic process where one lithospheric plate sinks beneath another into the mantle. While subduction can generate the magma that eventually forms plutons, it is not a mechanism for the emplacement itself.

198. (A) Brittle
Brittle behavior is a type of mechanical response where a material deforms by fracturing or breaking rather than by flowing or bending. This occurs when the applied stress exceeds the rock's strength before any significant plastic deformation can take place. Brittle deformation is characteristic of the upper crust, where temperatures and pressures are relatively low, leading to the formation of faults and joints.

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199. (A) Mineral lineation
A mineral lineation is a linear fabric element defined by the parallel alignment of elongate or needle-like mineral grains, such as amphiboles (hornblende) or sillimanite. This orientation typically occurs during deformation and metamorphism as minerals grow or rotate to align with the direction of maximum stretching or tectonic transport. This feature provides important information about the kinematic history and strain direction within the rock.

200. (B) 2, 3, 1
The order of increasing metamorphic grade is slaty cleavage, followed by schistosity, and

then gneissic banding. Slaty cleavage forms at low grades from very fine minerals. Schistosity develops at medium grades as minerals like micas grow larger and visible. Gneissic banding represents the highest grade, where minerals segregate into distinct compositional layers. This sequence reflects the progressive recrystallization of rock fabrics under increasing temperature and pressure.

201. (A) The apparent offset of the bed in a specific 2D view (e.g., a cliff face)
Separation is the apparent offset of a geological marker, such as a bedding plane, when observed in a particular two-dimensional cross-section or map view. It is important to distinguish this from slip, which is the true, three-dimensional displacement vector. Because separation depends on the orientation of the viewing surface relative to the fault and the bed, it can be misleading about the actual movement.

202. (A) Recrystallization and intracrystalline slip
Ductile deformation occurs through internal processes that allow a rock to change shape without fracturing. Key mechanisms include recrystallization, where new mineral grains grow in response to stress, and intracrystalline slip, where atoms move within a mineral's crystal lattice. These processes are favored by high temperatures and pressures, allowing the rock to flow plastically like a very stiff fluid over geological time.

203. (A) Simple shear
Simple shear is a type of non-coaxial deformation characterized by monoclinic symmetry. In this process, the rock deforms as parallel layers slide past each other, similar to the movement of a deck of cards. This leads to a single plane of symmetry in the resulting strain ellipsoid and rock fabric. It is a common mechanism in shear zones and reflects the directional nature of tectonic movement.

204. (D) Perfectly parallel and continuous sedimentary layers
Identifying a fault in the field involves looking for evidence of displacement, such as a fault scarp, slickensides, or the juxtaposition of different rock types. The presence of perfectly parallel and continuous sedimentary layers would actually indicate that no faulting has occurred. Faults, by definition, break the continuity of rock units and create recognizable structural and topographic indicators of movement within the crustal layers.

205. (A) Both Statement I and Statement II are correct
Ring dykes and cone sheets are both arcuate intrusions associated with volcanic centers, but they have different geometries. Ring dykes are vertical or steeply dipping, often forming circular patterns in plan view due to cauldron subsidence. Cone sheets are nested intrusions that dip inward toward a common central point at depth. Both statements accurately describe these characteristic features of magma tectonics and their respective structural orientations.

206. (A) The variation in thickness of the folded layers
The style of a fold, such as parallel or similar, is classified based on how the thickness of the individual layers changes throughout the structure. In parallel folds, the layer thickness remains constant, while in similar folds, the layers tend to thin on the limbs and thicken in the hinges. These variations reflect the different mechanical processes, like buckling or flow, that occurred during folding.

207. (A) A coarse-grained foliation defined by the parallel alignment of visible platy minerals
Schistosity is a prominent type of foliation found in medium-to-high-grade metamorphic rocks. it is characterized by the preferred orientation of platy minerals, most commonly micas, that have grown large enough to be clearly visible to the naked eye. This alignment gives the rock a distinctly layered or planar appearance and often a sparkly sheen. Schistosity indicates more intense recrystallization than slaty or phyllitic fabrics.

208. (A) Vertical component of dip slip
The throw of a fault is specifically the vertical component of the displacement, or net slip. It measures the vertical distance between two points that were originally together before faulting occurred. Heave is the corresponding horizontal component of the dip-slip. Both measurements are essential for quantifying the total movement on a fault and are particularly useful in practical applications like mining and stratigraphic correlation.

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209. (A) The conditions of pressure, temperature, and strain rate which determine if the rock behaves ductilely or brittly
Whether a rock folds or faults is determined by its mechanical behavior under stress. At shallower depths with lower temperatures and pressures, rocks tend to be brittle and will fracture or fault. At greater depths with higher temperatures and pressures, rocks become ductile and will bend or flow into folds. The strain rate also influences this transition, with faster rates promoting brittle failure over ductile flow.

210. (A) Both A and R are true and R is the correct explanation of A
In a plunging anticline, the entire arched structure is tilted. When this tilted fold is eroded to a flat surface, the outcrop of the dipping limbs creates a V-shape. According to geometric principles, the limbs of an anticline converge in the direction of the plunge. Therefore, the outcrop pattern V's" or closes in the direction that the fold axis is plunging, confirming both statements.

211. (C) Parallel strata with a non-erosional contact and a time gap
A paraconformity is a subtle type of unconformity where the sedimentary layers above and below the contact are parallel, and there is no visible erosional surface or discordance. Despite the conformable appearance, a significant interval of geologic time is missing from the record. Identifying a paraconformity typically requires detailed biostratigraphic analysis to detect the absence of fossil zones that should normally be present.

212. (C) The maximum shear stress, $(\sigma 1-\sigma 3)/2$
In a Mohr circle diagram, the horizontal axis represents normal stress and the vertical axis represents shear stress. The radius of the circle is equal to half the difference between the maximum and minimum principal stresses. This specific value represents the maximum shear stress acting within the rock at that state of stress. Understanding this relationship is critical for predicting when the rock will reach its failure limit.

213. (A) Interference patterns
Superimposed folding occurs when a second phase of deformation is applied to a rock that has already been folded. This second event refolds the existing structures, leading to the creation of complex interference patterns. Depending on the relative orientations of the two sets of folds, these patterns can include domes and basins or crescent" and mushroom" shapes, which reveal the polyphase tectonic history of the region.

214. (D) Reverse fault
A reverse fault is a structure that forms in a compressional stress regime where the rock behaves brittly and fractures. Under these conditions, the hanging wall is pushed upward relative to the footwall, effectively shortening the Earth's crust. This is distinct from folding, which is the ductile response to compression, and normal faulting, which is the brittle response to tensional stresses that pull the crust apart.

215. (A) Lineation
A lineation is a linear fabric element within a rock. In a deformed conglomerate, the individual pebbles can be stretched and aligned by tectonic forces into a preferred orientation. This linear arrangement of elongated objects provides a clear measure of the direction of maximum stretching or tectonic transport. Lineations are essential tools for geologists to reconstruct the orientation of the strain ellipsoid and the kinematic history.

216. (C) The fracturing and assimilation of overlying country rock
Stoping is a pluton emplacement mechanism where magma moves upward by fracturing the overlying country rock. Blocks of this rock, known as xenoliths, break off and sink into the magma. This process effectively makes space for the magmatic body and often leads to the chemical assimilation of some of the country rock material. Stoping allows magma to intrude without needing to forcefully push aside the wall rocks.

217. (D) Mineral composition has no influence on mechanical behavior
This statement is incorrect because mineral composition is a major factor influencing a rock's mechanical behavior. Different minerals have different strengths, melting points, and ductilities. For example, quartz-rich rocks behave differently than those rich in mica or calcite. Other key factors include temperature, confining

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pressure, and strain rate, all of which determine whether a rock will deform in a brittle or ductile manner under tectonic stress.

218. (A) Fault trace
The fault trace is the line produced by the intersection of a fault plane with the Earth's surface. On a geological map, this trace indicates the position and orientation of the fault. It is a critical feature for mapping tectonic structures. If the fault has recently moved and created a vertical step in the topography, that specific part of the trace is known as a fault scarp.

219. (B) Thinning of limbs and thickening of hinges
A similar fold is characterized by a style of folding where the layer thickness, measured parallel to the axial plane, remains constant. However, this geometric requirement means that the actual thickness of the layers, measured perpendicular to the bedding, must decrease on the limbs and increase in the hinges. Similar folds are common in rocks that have undergone significant ductile flow during the folding process.

220. (B) P-3, Q-4, R-1, S-2
An unconformity is often marked by a basal conglomerate. Faults are characterized by features like slickensides and fault gouge. Folds are defined by their hinges and limbs. Pluton emplacement occurs through mechanisms like stoping and diapirism. These various features and processes are the fundamental building blocks of structural geology, allowing for the identification and interpretation of the Earth's complex tectonic and magmatic history.

221. (A) Unaxial flattening
Uniaxial flattening is a type of strain where a material is compressed along one axis and expands equally in all directions perpendicular to that axis. In this scenario, an original sphere would be deformed into a flattened, pancake-like ellipsoid. This type of strain is common in tectonic environments dominated by pure shortening, resulting in the development of a strong foliation with little to no linear fabric.

222. (A) Surface representing a gap in the geologic record (a period of non-deposition or erosion)
An unconformity is a fundamental geological concept representing a significant break in the continuity of the stratigraphic record. It is a surface that marks a period of time during which either no sediments were deposited or existing rocks were eroded away. Unconformities are essential for dividing the rock record into distinct sequences and for understanding the history of uplift, erosion, and tectonic activity.

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223. (A) The orientation of the hinge line (inclined vs. horizontal)
The fundamental difference between a plunging and a non-plunging fold is the orientation of the hinge line. In a non-plunging fold, the hinge line is horizontal. In a plunging fold, the hinge line is inclined at an angle to the horizontal plane. This difference in orientation results in very different outcrop patterns on geological maps, with plunging folds creating V-shaped or U-shaped patterns.

224. (B) An overturned fold or a thrust fault
The repetition of a specific stratigraphic sequence, such as B-C-D appearing twice in the order A-B-C-D-B-C-D-E-F, indicates that the rock layers have been duplicated. This can occur either through an overturned fold, where the strata are folded back on themselves, or through a thrust fault, which pushes an older section of rock up and over a younger one. Both reflect significant crustal shortening.

225. (B) Transtensional fault
A transtensional fault is a type of strike-slip fault that also has a component of extensional or normal fault motion. This occurs when the regional stress field involves both shear and tension, causing the crust to both slide horizontally and pull apart. Transtensional zones are common at bends in strike-slip faults and often lead to the formation of localized down-dropped basins called pull-apart basins.

226. (C) Statement I is correct, but Statement II is incorrect
Joints and fractures significantly increase the secondary porosity and permeability of rocks by providing open pathways for fluids. However, the second statement is incorrect because slaty cleavage is characteristic of low-grade metamorphic rocks like slate. In high-grade rocks like gneiss, the tectonic fabric is instead characterized by gneissic banding, where minerals

are segregated into distinct compositional layers through intense recrystallization at high temperatures.

227. (A) Rock failure as described by the Mohr-Coulomb failure criterion
The mechanics of faulting is fundamentally based on the concept of rock failure. The Mohr-Coulomb failure criterion provides a mathematical and graphical way to describe the relationship between shear and normal stresses at which a rock will fracture. It explains how different stress states, represented by Mohr circles, lead to brittle failure when they reach a critical threshold, effectively controlling when and where faults form.

228. (A) The geometric arrangement of mineral grains and internal structures resulting from deformation
A tectonic fabric refers to the systematic geometric arrangement of a rock's internal components, such as mineral grains, pebbles, or fossils, that was produced during deformation. Fabrics can be planar (foliation), linear (lineation), or a combination of both. By studying these fabrics, geologists can infer the type of strain, the orientation of the stress axes, and the kinematic history of the deformed rock mass.

229. (A) Magma tectonics
Magma tectonics is the study of the structures and deformation produced by the movement and emplacement of magma within the Earth's crust. Ring dykes and cone sheets are classic features of this process. They form around volcanic centers in response to localized stress fields created by the pressure and movement of magma, providing important clues about the dynamics of igneous systems and the formation of calderas.

230. (D) 1, 2 and 3
All three statements correctly describe fundamental fold types. An anticline is arched upward, while a syncline is bowed downward and preserves the youngest rocks in its core. A monocline is a simple, step-like fold with a single dipping limb connecting two horizontal sections. These definitions are essential for accurately identifying and mapping the various ways that rock layers can be bent in response to tectonic forces.

231. (A) The maximum principal stress ($\sigma 1$)
In a Mohr circle diagram, the horizontal axis represents normal stress. The two points where the circle intersects this axis represent the principal stresses. The point furthest to the right has the highest value of normal stress and therefore represents the maximum principal stress. The point furthest to the left represents the minimum principal stress. The distance between them is the differential stress.

232. (A) The younger fold set will deform the axial planes and limbs of the older fold set
In areas with multiple deformational events, geologists use cross-cutting and overprinting relationships to distinguish between fold sets. A younger fold set will deform the features created by an older set, such as its axial planes, hinges, and associated foliations. This leads to the formation of refolded folds and complex interference patterns, which are key for reconstructing the sequence of tectonic events in the region.

233. (B) Plate tectonics
The primary driver of stress in the Earth's lithosphere is plate tectonics. The constant movement of tectonic plates—as they collide, pull apart, or slide past each other—generates massive amounts of stress within the crustal rocks. When this accumulated stress exceeds the strength of the rock, it causes the crust to fracture and fault, leading to earthquakes and the long-term deformation of the lithosphere.

234. (A) A combination of strike-slip and dip-slip movement
An oblique-slip fault is characterized by displacement that has significant components of both horizontal (strike-slip) and vertical (dip-slip) motion. This means the movement is not purely up-and-down or side-to-side. Most natural faults exhibit some degree of oblique motion, although they are often classified by whichever component is more dominant. Oblique-slip reflects a complex regional stress field that is not perfectly aligned with the fault's strike.

235. (C) Gouge
Fault gouge is a very fine-grained, clay-rich material that forms in fault zones as a result of the intense grinding and crushing of rock during displacement. It is often incohesive and has a

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flour-like or clayey texture. Gouge is a product of brittle deformation at relatively shallow depths. Its presence can significantly affect the mechanical properties and fluid permeability of the fault zone, influencing future movement and fluid flow.

236. (A) Metamorphic
The term foliation specifically refers to a pervasive, planar fabric developed in metamorphic rocks due to tectonic deformation. It is created as mineral grains rotate or recrystallize to align themselves perpendicular to the direction of maximum compression. Common types include slaty cleavage, schistosity, and gneissic banding. While sedimentary and igneous rocks can have layering, the term foliation is reserved for these tectonically induced metamorphic fabrics.

237. (A) buckle; flow
In the mechanics of folding, different rock types respond differently based on their relative stiffness. Competent layers, which are strong and stiff, tend to maintain their thickness and buckle into wave-like forms. Incompetent layers, which are weak and less stiff, respond by flowing and thinning on the limbs while thickening in the hinges. This contrast in behavior is fundamental to the development of complex fold styles in heterogeneous rock sequences.

238. (A) Pure constriction (prolate strain)
An L-tectonite is a rock whose tectonic fabric is dominated by linear elements with little to no foliation. This type of fabric is typically produced by a state of pure constriction, also known as prolate strain. In this strain environment, the rock is stretched significantly along one axis and shortened in all directions perpendicular to that axis, causing mineral grains to align into a strong linear fabric.

239. (A) Diapirism
Diapirism is the buoyant rise of a low-density body through denser surrounding material. A salt dome is a classic example, where a layer of salt flows and rises through overlying sedimentary rocks due to its lower density. This same physical process is a primary mechanism for the emplacement of many magmatic plutons, where buoyant magma forcefully displaces and deforms the crustal rocks as it ascends.

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240. (A) Both A and R are true and R is the correct explanation of A
Slaty cleavage is the characteristic foliation of low-grade metamorphic rocks like slate. It forms as fine-grained minerals, particularly clays and micas, align themselves in response to tectonic compression. This process involves both the mechanical rotation of existing grains and the growth of new minerals through pressure solution and recrystallization. These processes create a pervasive planar fabric that allows the rock to split into thin sheets.

241. (A) Stress is force per unit area; strain is the resulting deformation or change in shape
Stress and strain are related but distinct physical concepts. Stress is the causal force, defined as the intensity of the internal resistance within a material to an external load, measured as force per unit area. Strain is the physical consequence of that stress, representing the actual change in the shape, volume, or dimensions of the material. Understanding the relationship between them is fundamental to structural geology.

242. (A) Angular unconformity
An angular unconformity is a structural relationship where a set of horizontal sedimentary layers rests upon the eroded surface of an older set of tilted or folded rock layers. This feature indicates a significant sequence of geological events: deposition of the older layers, their subsequent deformation and tilting, a period of erosion that creates a flat surface, and finally the deposition of the younger horizontal strata.

243. (B) Sides or flanks of the fold between the hinges
In fold geometry, the limbs are the flanking regions of the fold that lie on either side of the hinge. The hinge is the line where the rock layers turn most sharply. For an anticline or syncline, the limbs dip either away from or toward the axial plane, respectively. The relative length and dip of the limbs are used to classify folds as symmetrical or asymmetrical.

244. (A) Nappe
A nappe is a very large-scale, sheet-like rock mass that has been moved horizontally over great distances, often tens of kilometers, along a thrust fault. Nappes frequently consist of large recumbent folds where the lower limb has

been sheared out. These massive structures are common in complex mountain belts like the Alps and represent extreme crustal shortening and tectonic transport during continental collisions.

245. (A) Horizontally offset features like streams or fences
The most definitive evidence for a strike-slip fault is the horizontal displacement of features that cross the fault line. This can include natural features like stream channels or man-made structures like fences and roads. Unlike other faults that primarily show vertical displacement, strike-slip faults involve blocks of rock sliding past each other, making these horizontal offsets the primary field indicator for their identification and measurement.

246. (B) Schistosity
Schistosity is a type of foliation, which is a planar fabric element defined by the parallel alignment of platy mineral grains. It is not a lineation. Lineations are linear fabric elements, such as the alignment of needle-like minerals, striations on a fault surface, or the intersection of two planar features. Distinguishing between planar foliations and linear lineations is essential for accurately describing and analyzing deformed rock fabrics in the field.

247. (A) How rock layers bend and deform to form folds
The mechanics of folding is the study of the physical processes and environmental conditions that lead to the bending and deformation of rock layers. This involves analyzing how factors like rock stiffness, layer thickness, temperature, and pressure interact with tectonic stresses to produce different fold styles, such as buckling or flow. Understanding these mechanics is essential for reconstructing the deformation history of the Earth's crust.

248. (B) $\sigma 1$ is vertical, $\sigma 3$ is horizontal
According to Anderson's theory, normal faults form in tensional stress regimes where the maximum principal stress is vertical, exerted by the weight of the overlying rock layers. The minimum principal stress is oriented horizontally. This configuration allows the crust to extend horizontally as the rock fractures and the hanging wall moves downward along the inclined fault plane, which is the most efficient way to accommodate the strain.

249. (A) The collapse of the roof of a magma chamber
Cauldron subsidence is a mechanism of magma tectonics where a large, circular or arcuate block of the Earth's crust collapses into an underlying magma chamber. This collapse is typically triggered by the withdrawal of magma, which removes the internal support for the roof rock. The sinking of the central block occurs along vertical or steeply dipping fractures, which are often subsequently filled by magma to form ring dykes.

250. (C) P-3, Q-4, R-1, S-2
Stress is the force per unit area acting on a material, while strain is the resulting change in shape or volume. Ductility is the physical property that allows a rock to undergo significant permanent deformation without fracturing. Brittleness is the opposite, where the rock fractures at very low strain. These four concepts are the foundation of rock mechanics and are used to explain how geological structures form.

251. (C) Mohr Circle
The Mohr circle is a powerful graphical tool used in two-dimensional stress analysis to visualize the state of stress at a point. By plotting shear stress against normal stress, it represents the stresses acting on all possible planes passing through that point. Geologists use Mohr circles to determine the principal stresses and to analyze how close a rock is to reaching the failure conditions defined by the failure envelope.

252. (A) Gentle
Folds are classified based on their inter-limb angle, which is the angle between the two limbs. A gentle fold is one with a large inter-limb angle, typically between 120 and 180 degrees. This indicates a relatively low amount of deformation. As the angle decreases, the fold is classified as open, then tight, and finally isoclinal when the limbs become parallel. Gentle folds are common in the outer parts of mountain belts.

253. (C) Statement I is correct, but Statement II is incorrect
In a reverse fault, the hanging wall is pushed upward relative to the footwall, which is a correct

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description of the motion. However, the second statement is incorrect because reverse faults are caused by compressional stress, not tensional stress. Compressional forces act to shorten the crust, forcing the blocks to move over one another. Tensional stress instead pulls the crust apart, which leads to the formation of normal faults.

254. (A) It is a set of discrete, parallel micro-fractures, not a pervasive mineral fabric
Fracture cleavage is a type of secondary planar fabric that consists of a set of closely spaced, parallel micro-fractures. It is distinct from slaty cleavage or schistosity because it is not defined by the preferred orientation of mineral grains like micas. Instead, it represents a brittle response to stress where the rock breaks along these discrete surfaces. Fracture cleavage is often found in more competent, brittle rock layers.

255. (B) Limbs are parallel to one another
An isoclinal fold is a type of fold where the two limbs have been squeezed so tightly that they are parallel or nearly parallel to each other and to the axial plane. This means the inter-limb angle is zero or near zero. Isoclinal folds reflect a high degree of tectonic strain and crustal shortening, often occurring in the intensely deformed cores of mountain belts where rocks behave in a highly ductile manner.

256. (B) Cooling and contraction of an igneous body
Joints are fractures along which no significant movement has occurred. They commonly form in igneous rocks due to the tensional stresses created as the rock cools and contracts. A well-known example is columnar jointing in basalt. Other major causes of joints include regional tectonic stresses and the removal of overlying weight through erosion, known as unloading, all of which exceed the rock's tensile strength and cause it to crack.

257. (A) thrust sheet; footwall rocks
A window, or fenster, is a structural feature formed when erosion cuts through an overthrust rock mass, known as a thrust sheet or nappe. This erosional hole exposes the younger rocks of the footwall that were overridden by the thrust. Windows are valuable to geologists because they provide a direct look at the underlying stratigraphic sequence, confirming the presence of large-scale horizontal tectonic displacement in the region.

258. (D) They are primarily caused by tensional stress
This is an incorrect statement because strike-slip faults are primarily produced by shear stress, where blocks of rock slide past each other horizontally. Tensional stress pulls the crust apart and leads to normal faults. Strike-slip faults can be dextral (right-lateral) or sinistral (left-lateral), and they are often vertical or near-vertical. These faults play a major role in accommodating horizontal plate motion, such as at transform boundaries.

259. (C) Fault
While a contact where sedimentary rocks overlie older crystalline rocks is often a nonconformity, the specific classification of this contact as a fault implies that tectonic movement has occurred along the surface. Faults can juxtapose rock units of different ages and types. In this case, the contact is defined by a fracture across which there has been measurable displacement, rather than being a simple erosional surface where new sediments were deposited.

260. (D) 1, 2 and 3
These three statements correctly define the primary classification of faults based on the direction of movement along the fault plane. Dip-slip faults involve motion parallel to the dip, strike-slip faults involve horizontal motion parallel to the strike, and oblique-slip faults combine both components. This classification is fundamental for structural geologists when analyzing the kinematic history and the orientation of the stress field that produced the faulting.

261. (A) A straight line that is unaffected by topography
On a topographic map, the outcrop of a rock layer that dips vertically will appear as a perfectly straight line. Because the bed is vertical, its position on the surface is not influenced by the shape of the terrain, such as hills or valleys. This follows the geometric principle that the intersection of a vertical plane with any topographic surface will always project as a straight line on a horizontal map.

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262. (A) Recrystallization and intracrystalline slip
Ductile deformation allows rocks to change their shape permanently without fracturing. This occurs through internal processes such as recrystallization, where mineral grains change shape or size, and intracrystalline slip, where atoms move along planes within the crystal lattice. These mechanisms are favored by high temperatures and confining pressures, which provide the energy and environment necessary for minerals to flow like a very viscous fluid under tectonic stress.

263. (A) The movement picture or kinematics of the deformation
The concept of symmetry in deformed rock fabrics and structures is a fundamental tool for structural analysis. By observing whether a fabric has orthorhombic, monoclinic, or triclinic symmetry, geologists can infer the movement picture" or kinematics of the deformation. For example, monoclinic symmetry often indicates non-coaxial strain like simple shear. This symmetry analysis helps reconstruct the directions of tectonic transport and the overall style of deformation in a region.

264. (A) A U-shape or V-shape that closes in the direction of plunge
A plunging anticline is an arched fold with an inclined hinge line. When this tilted structure is eroded and viewed on a geological map, the outcrop of the dipping rock layers forms a distinctive V-shape or U-shape. For an anticline, this pattern closes or V's" in the direction of the plunge. These map patterns are essential tools for geologists when mapping the three-dimensional geometry of fold systems.

265. (C) Heave is vertical displacement; throw is horizontal
This statement is actually incorrect as it swaps the standard definitions. In structural geology, throw is defined as the vertical component of the net slip, while heave is the horizontal component of the dip-slip. Together, throw and heave describe the vertical and horizontal aspects of displacement in a dip-slip fault. These measurements are used by geologists to quantify the total movement and the resulting changes in crustal thickness and width.

266. (B) Boudin
A boudinage structure is a linear feature formed when a competent rock layer, like sandstone, is stretched and breaks into a series of sausage-shaped segments. These segments, or boudins, are separated by the flow of the surrounding incompetent material, such as shale. The term comes from the French word for sausage. Boudinage is a clear indicator of stretching within a rock sequence and reveals the relative competence of different layers.

267. (A) Both Statement I and Statement II are correct
Both statements provide accurate summaries of fundamental structural principles. The mechanics of folding involves two primary processes: buckling, caused by layer-parallel compression, and bending, caused by forces perpendicular to the layering. The mechanics of faulting are well-explained by Anderson's theory, which links the type of fault to the orientation of the maximum, intermediate, and minimum principal stresses. These theories form the foundation for interpreting crustal deformation.

268. (A) Forceful injection
Forceful injection is a mechanism of pluton emplacement where a buoyant magma body actively pushes aside and deforms the surrounding country rock as it rises. This process often results in the formation of concordant structures, where the country rock's fabric and folds are oriented parallel to the margin of the pluton. This suggests that the magmatic body was an active agent that forcefully created its own space within the Earth's crust.

269. (A) Listric fault
A listric fault is a type of normal fault characterized by a curved fault plane that becomes progressively shallower or less steep with depth. This results in the hanging wall block rotating as it moves downward, often leading to the formation of a half-graben basin. Listric faults are common in regions of crustal extension, such as along rifted continental margins, where they accommodate significant amounts of stretching and thinning.

270. (A) Both A and R are true and R is the correct explanation of A
Joints are indeed the most common and widespread type of geological structure. They

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form in response to various universal processes such as the cooling of igneous rocks, the removal of overlying weight through erosion (unloading), and regional tectonic stresses. Because rocks are generally much weaker in tension than in compression, these tensional forces easily cause the crust to fracture into joints across almost all rock types and geographic regions.

271. (C) It has no effect on the rock's strength
This is actually an incorrect statement because an increase in pore fluid pressure significantly reduces a rock's shear strength. By exerting outward pressure within the pores, the fluid counteracts the confining pressure, thereby reducing the effective normal stress on potential failure planes. This makes it easier for the rock to fracture or fault. Therefore, fluid pressure is a critical factor in promoting rock failure and seismic activity within the Earth's crust.

272. (A) Inclined
A fold is classified as inclined when its axial plane is neither vertical nor horizontal. Specifically, the dip of the axial plane for an inclined fold typically ranges between 10 and 80 degrees. This classification helps describe the orientation of the fold in space, reflecting the direction and intensity of the tectonic forces that produced it. Inclined folds are very common in most deformed mountain belts and structural provinces worldwide.

273. (C) Forms parallel bands
For a non-plunging syncline, the outcrop pattern on a perfectly level surface consists of a series of parallel bands of rock strata. These bands are oriented parallel to the horizontal fold axis. Because it is a syncline, the youngest rocks are located in the central band or core, with progressively older rock layers appearing symmetrically on either side as you move outward onto the limbs. This pattern is essential for structural mapping.

274. (A) Transform fault
A transform fault is a large-scale strike-slip fault that functions as a plate boundary, allowing two tectonic plates to slide horizontally past one another. The San Andreas Fault is a well-known example. Unlike other strike-slip faults, transform faults connect different types of plate boundaries, such as two segments of an oceanic ridge. They accommodate the differential motion between plates and are significant sources of seismic activity and crustal deformation.

275. (A) Deformed metamorphic rocks
Foliation is a pervasive planar fabric defined by the preferred orientation of mineral grains, such as micas or elongated minerals. This is a characteristic feature of metamorphic rocks that have undergone deformation. During the metamorphic process, minerals align themselves perpendicular to the direction of maximum tectonic shortening to minimize stress. This alignment creates the layered or planar appearance typical of rocks like slate, schist, and gneiss, reflecting their tectonic history.

276. (B) Diapirism
The buoyant rise of a low-density magma body through denser surrounding rock is a mechanism of pluton emplacement called diapirism. This process is driven by gravitational instability, where the lighter magma moves upward to achieve a stable position. As the magmatic diapir ascends, it forcefully displaces and deforms the overlying country rock, often creating distinctive concordant structures in the surrounding area, similar to the movement of salt in salt domes.

277. (B) Vertical component of dip-slip
This statement is actually incorrect as it swaps the standard definitions. In structural geology, heave is defined as the horizontal component of the displacement in a dip-slip fault, while throw is the vertical component. Both are important for quantifying how much a fault has moved. Heave measures how much the blocks have moved apart or toward each other horizontally, which is essential for calculating the total crustal extension or shortening.

278. (D) Intersection lineation
Foliation is a general term for planar fabrics in rocks, such as slaty cleavage, schistosity, and gneissic layering, which result from mineral alignment. Intersection lineation, however, is a linear fabric element formed by the crossing of two planar surfaces. While it often lies within a foliation plane, it is geometrically a line rather than a plane. Distinguishing between planar foliations and linear lineations is fundamental

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for accurately describing and analyzing deformed rock structures.

279. (B) Folds, reverse faults, and thrust faults
In a compressional tectonic setting, where the Earth's crust is being squeezed and shortened, the most common structures are folds, reverse faults, and thrust faults. These features allow the crustal rocks to accommodate the shortening by bending or by breaking and pushing rock masses over one another. This type of deformation is characteristic of convergent plate boundaries, where mountain belts are formed through intense compression and crustal thickening.

280. (C) P-4, Q-1, R-2, S-3
An anticline is arched upward (convex up), while a syncline is bowed downward (concave up). A dome is an antiform that dips away from a center in all directions, and a basin is a synform that dips toward a central point from all sides. These definitions are fundamental for structural geology, providing a clear geometric framework for identifying and mapping the various ways that tectonic forces bend rock layers.

281. (B) Stress and strain
This is an incorrect description. The Mohr-Coulomb failure criterion actually describes the relationship between shear stress and normal stress at which a rock will undergo brittle fracture, not the relationship between stress and strain. It provides a mathematical boundary that determines when the internal strength of a rock is overcome by tectonic forces. This criterion is fundamental for predicting the conditions under which faults and other brittle fractures will form in the crust.

282. (C) Paleontological evidence indicating a significant time gap
Because a paraconformity lacks visible angular discordance and often lacks an obvious erosional surface, it is extremely difficult to identify based on physical features alone. The most reliable way to recognize a paraconformity is through paleontological evidence. By identifying a significant gap in the fossil sequence, geologists can prove that a long interval of geologic time is missing from the record, despite the strata appearing perfectly conformable and continuous in the field.

283. (C) It only affects the limbs, not the hinges of the earlier folds
This statement is incorrect as a second phase of deformation typically affects all parts of an existing fold structure. When a new stress field is applied, it refolds both the limbs and the hinges of the earlier folds, creating complex interference patterns. This process can produce intricate geometries like mushroom" or crescent" shapes. These refolded structures are powerful indicators of a polyphase tectonic history, where multiple separate events have shaped the rock.

284. (D) Symmetrical rock layers
This statement is incorrect because the presence of perfectly symmetrical rock layers would typically indicate that no faulting has occurred. Instead, recognizing a fault involves identifying features that break the expected geological pattern, such as the juxtaposition of different rock types or ages that are not in their normal stratigraphic order. Other key indicators include fault scarps, slickensides, and the truncation of pre-existing structures like bedding or mineral veins.

285. (A) Mineral lineation
A mineral lineation is a linear fabric element within a rock defined by the parallel alignment of the long axes of elongate mineral grains. Common minerals that form lineations include hornblende, actinolite, or sillimanite. This preferred orientation typically occurs during deformation and metamorphism, as the minerals rotate or grow to align with the direction of maximum stretching. This feature provides direct evidence of the kinematic path taken by the rock during deformation.

286. (B) Bending
This statement is actually incorrect as the described mechanism is buckling, not bending. Buckling involves layer-parallel compression, much like compressing a deck of cards or a thin metal sheet from the ends, causing it to deform into wave-like folds. The wavelength of these folds is controlled by the thickness and stiffness of the layers. Bending, in contrast, involves forces acting perpendicular to the layering, which produces a different style of fold structure.

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287. (C) L-tectonite
This statement is incorrect as a rock with both a strong foliation and a strong lineation is actually called an LS-tectonite. An L-tectonite is a rock whose fabric is dominated purely by linear elements, reflecting a state of strain where stretching in one direction is the primary feature. LS-tectonites are common in high-strain environments like shear zones, where they reveal a complex, three-dimensional tectonic history involving both flattening and one-dimensional stretching of mineral grains.

288. (A) A regional compressional field associated with plate convergence
This is an incorrect statement. Cone sheets are actually thought to form in a localized stress regime created by the upward pressure of magma within a central chamber. This pressure generates conical tensional fractures in the overlying rock, into which magma is then injected. Therefore, cone sheets are not products of large-scale regional compression associated with plate convergence, but rather are specific indicators of active magmatic forces and local vertical stress within the crust.

289. (A) Footwall
In structural geology, the footwall is the block of rock that resides physically below an inclined fault plane. This term originates from mining, as it was the surface on which the miner would stand or walk. The block above the fault is the hanging wall. Identifying the footwall and its relative movement is essential for determining the type of fault—such as whether the hanging wall has moved down (normal fault) or up (reverse fault).

290. (D) 1, 2 and 3
All three statements provide accurate descriptions of basic fold geometry and their map patterns. In an anticline, layers dip away from the axial plane, while in a syncline, they dip toward it. Non-plunging folds, where the hinge line is horizontal, create a simple map pattern of parallel bands of rock layers. These fundamental relationships are used by geologists to identify and map the structural architecture of the crust and to reconstruct ancient tectonic forces.

291. (A) Tensional stresses created during the cooling and contraction of the lava
Columnar joints are a primary structure commonly found in basaltic lava flows and shallow intrusions. They are produced by tensional stresses that develop as the igneous body cools and contracts. The cooling causes the rock to shrink toward a series of centers, creating a systematic pattern of polygonal, prismatic fractures. This process results in the formation of striking, parallel columns, such as those seen at Giant's Causeway or Devils Tower.

292. (A) The three principal stresses ($\sigma 1$, $\sigma 2$, $\sigma 3$) and their orientations
To fully define the state of stress at any point in three-dimensional space, one must know the magnitudes and the orientations of the three principal stresses. These stresses are mutually perpendicular. This complete stress tensor allows geologists to calculate the normal and shear stresses acting on any plane passing through that point. Understanding this three-dimensional stress state is fundamental for predicting rock failure, faulting, and the development of complex tectonic structures.

293. (C) A fault with large displacement
This is an incorrect statement because an unconformity is a surface representing a gap in the stratigraphic record, not a fault. It marks a period of non-deposition or erosion. A fault, in contrast, is a fracture across which there has been measurable displacement between two rock blocks. While both are important structural features, they represent very different geological processes: one involving a break in time and the other involving mechanical failure and movement.

294. (B) Upright fold
This is incorrect because an upright fold is defined by having a vertical or near-vertical axial plane. A fold with an essentially horizontal axial plane is specifically classified as a recumbent fold. Recumbent folds indicate extreme deformation and significant horizontal transport, often occurring in the complex cores of mountain belts. In contrast, upright folds reflect simpler, more vertical patterns of crustal shortening where the compressional forces are primarily balanced and horizontal.

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295. (B) 3, 1, 2, 4
This sequence orders fault rocks based on increasing deformation and depth. Fault breccia consists of coarse, angular fragments formed by brittle crushing at shallow levels. Gouge is a finer-grained, clay-rich product of further mechanical grinding. Mylonite represents ductile deformation occurring at higher temperatures and pressures deeper in the crust. Pseudotachylite is a glass-like rock formed by extreme frictional heating during rapid seismic slip, representing a highly specialized and intense deformational product.

296. (A) Left-lateral strike-slip fault
A sinistral fault is a type of strike-slip fault where the block of rock on the opposite side of the fault moves to the observer's left. This term is synonymous with left-lateral motion. Strike-slip faults are characterized by horizontal displacement parallel to the strike of the fault plane and are produced by shear stresses within the Earth's crust. Distinguishing between sinistral and dextral (right-lateral) motion is fundamental for analyzing regional tectonic movement.

297. (A) Both Statement I and Statement II are correct
Both statements provide accurate definitions of fundamental structural fabrics. Foliation is a pervasive planar fabric, common in metamorphic rocks, resulting from the parallel alignment of platy or elongated minerals. Lineation is a linear fabric element, such as aligned mineral grains or intersection lines. These fabrics provide crucial information about the history of strain and the orientation of tectonic forces. Both are essential tools for geologists when mapping and interpreting deformed rock terranes.

298. (D) Flexural slip
Flexural slip is a folding mechanism where rock layers slide past one another to accommodate the bending of the overall structure. This process is common in well-bedded, competent rock sequences. It is similar to what happens when you bend a thick book; the individual pages must slip relative to each other for the stack to curve. This mechanism allows the layers to maintain their original thickness while undergoing significant changes in shape during the folding process.

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299. (A) The geometric arrangement of its constituent parts as a result of deformation
The tectonic fabric of a rock refers to the systematic geometric arrangement of its internal components—such as mineral grains, pebbles, or fossils—that was produced during tectonic deformation. These fabrics can be planar (foliation), linear (lineation), or a combination of both. By studying the tectonic fabric, geologists can reconstruct the kinematic history, determine the direction of tectonic transport, and infer the orientation and magnitude of the strain that affected the rock mass.

300. (B) Diapirism
Diapirism is a mechanism of pluton emplacement where a body of relatively low-density magma rises through the Earth's crust because it is more buoyant than the surrounding, denser country rock. Driven by gravitational instability, the magmatic body moves upward, forcefully displacing and deforming the overlying rocks. This process is similar to the movement of salt in salt domes and often results in the formation of distinctive concordant structures in the surrounding metamorphic rocks.

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CHAPTER 03
Mineralogy and Geochemistry

1. Which of the following sulfide minerals is an example of the AX type structure?
(A) Pyrite
(B) Galena
(C) Chalcopyrite
(D) Chalcocite

2. Consider the following statements regarding polymorphism:
Statement I : Polymorphism is the ability of a substance to crystallize into different crystal structures.
Statement II : The different structures of a polymorphic substance are chemically identical.
Which of the above statements is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

3. Consider the following statements regarding oxide minerals:
1. The XO type includes minerals like Periclase.
2. The XO_2 type is represented by minerals like Rutile.
3. The $XY2O_4$ type is characteristic of the Spinel group.

Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

4. The mineral Pyrite (FeS_2) is a representative of which sulfide structural type?
(A) AX type
(B) A2X type
(C) AX3 type
(D) AX2 type

5. Which of the following is the most appropriate definition of isomorphism in mineralogy?
(A) Minerals with the same chemical composition but different crystal structures.
(B) The process of unmixing of a solid solution during cooling.
(C) Minerals with the same crystal structure but different chemical compositions.
(D) The formation of a single mineral phase from a melt of complex composition.

6. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : Calcite and aragonite are polymorphs of calcium carbonate ($CaCO_3$).
Reason (R) : They have identical chemical compositions but differ in their crystal systems and physical properties.
Which of the following is correct?
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

7. Which of the following statements about the calcite group of carbonates is correct?
(A) Every known member belonging to this group is categorized in the orthorhombic system.
(B) Dolomite is recognized as being the principal mineral member within the calcite group.
(C) This group consists primarily of carbonate minerals containing structural water molecules.
(D) They have a general formula of RCO_3 and belong to the trigonal crystal system.

8. The process of exsolution is a direct result of:
(A) the breakdown of a solid solution that is stable only at high temperatures.
(B) a change in pressure and temperature leading to polymorphic transformation.
(C) the replacement of one ion by another of similar size and charge.

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(D) the radioactive decay of elements within a crystal lattice.

9. Match List I with List II and select the correct answer using the codes given below:
List I: (Oxide Type)
P. XO
Q. XO_2
R. $X2O_3$
S. XY_2O_4
List II: (Example Mineral)
1. Corundum
2. Spinel
3. Periclase
4. Rutile
Codes:
(A) P-3, Q-4, R-1, S-2
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-1, R-4, S-2
(D) P-4, Q-3, R-2, S-1

10. All of the following are examples of anhydrous sulfates EXCEPT:
(A) Gypsum
(B) Barite
(C) Anhydrite
(D) Celestite

11. What is the effect on the crystal lattice when one ion substitutes for another in an isomorphous series?
(A) The fundamental crystal structure of the mineral changes into a new phase.
(B) The mineral undergoes a process of exsolution into two distinct phases.
(C) The mineral becomes entirely amorphous and loses its defined crystal form.
(D) The lattice dimensions change slightly, though the overall structure remains.

12. Arrange the following silicate structures in order of increasing complexity of silica tetrahedra linkage:
1. Sheet silicates
2. Single chain silicates
3. Framework silicates
4. Isolated tetrahedra silicates
Select the correct answer using the code given below:
(A) 4, 2, 1, 3
(B) 1, 2, 3, 4
(C) 4, 1, 2, 3
(D) 2, 4, 1, 3

13. Chalcocite (Cu_2S) is an example of which type of sulfide?
(A) AX
(B) AX2
(C) A2X
(D) A3X2

14. Which of the following is an identifying characteristic of the aragonite group of carbonates?
(A) They are minerals that crystallize primarily within the hexagonal system.
(B) They are identified by their characteristic perfect rhombohedral cleavage.
(C) They are simple carbonates containing magnesium as a principal component.
(D) They are anhydrous RCO_3 carbonates that belong to the orthorhombic system.

15. What is the basic structural unit of all silicate minerals?
(A) A silicon atom bonded to four oxygen atoms (SiO_4)
(B) A silicon atom bonded to six oxygen atoms (SiO_6)
(C) A silicon atom bonded to three oxygen atoms (SiO_3)
(D) A silicon atom bonded to two oxygen atoms (SiO_2)

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16. Which of the following statements concerning the spinel group ($XY2O_4$ type) is incorrect?
(A) It includes important minerals like magnetite and chromite.
(B) All minerals in this group are silicates.
(C) The general formula is $XY2O_4$, where X and Y are cations.
(D) They belong to the oxide class of minerals.

17. The relationship between calcite and aragonite provides a classic example of which mineralogical phenomenon?
(A) Isomorphism
(B) Polymorphism
(C) Twinning
(D) Exsolution

18. Which of the following pairs of mineral groups and their basic structural classification is correctly matched?
(A) Olivine - Isolated tetrahedra silicates
(B) Pyroxenes - Double chain silicates
(C) Amphiboles - Sheet silicates
(D) Micas - Single chain silicates

19. Dolomite is a member of the dolomite group of carbonates. What is its chemical formula?
(A) $CaCO_3$
(B) $MgCO_3$
(C) $CaMg(CO_3)_2$
(D) $FeCO_3$

20. Which of the following conditions most favors the formation of aragonite over calcite?
(A) Low pressure and low temperature
(B) High temperature and low pressure
(C) Presence of excess silica in the solution
(D) High pressure and relatively low temperature

21. In the classification of silicate structures, what is the Si:O ratio for single chain silicates (inosilicates)?
(A) 1:4
(B) 2:7
(C) 1:3
(D) 2:5

22. A mineral with the chemical formula $BaSO_4$ is classified as a(n):
(A) Oxide
(B) Anhydrous sulfate
(C) Sulfide
(D) Hydrous sulfate

23. Which of the following mineral properties is NOT primarily dependent on its atomic structure?
(A) Hardness
(B) Cleavage
(C) Crystal form
(D) Color

24. The fundamental difference between pyroxenes and amphiboles lies in their:
(A) silicate structure, with pyroxenes being single chains and amphiboles double.
(B) chemical composition, with pyroxenes entirely lacking any hydroxyl ions.
(C) typical geological occurrence, with pyroxenes found only in metamorphic rocks.
(D) crystal system, with pyroxenes being orthorhombic and amphiboles monoclinic.

25. The general formula for feldspathoid minerals shows that they are:
(A) richer in silica compared to feldspars.
(B) chemically identical to feldspars but with a different structure.
(C) poorer in silica compared to feldspars.
(D) hydrous silicates containing molecular water.

26. Which of the following statements accurately describes the pyroxene group?
(A) They are single-chain silicates with a characteristic cleavage angle of near 90°.
(B) They are double-chain silicates with a standard silica to oxygen ratio of 4:11.
(C) They are categorized as sheet silicates exhibiting perfect basal cleavage planes.
(D) They are silicate minerals that always contain hydroxyl groups in the structure.

27. Based on atomic structure, which mineral group is characterized by containing the $(Al, Si)_4 O_{10}$ sheet?
(A) Pyroxene group
(B) Amphibole group
(C) Feldspar group
(D) Mica group

28. Zeolites are a group of minerals known for their ability to lose and regain water without changing their crystal structure. This property is due to their:
(A) structural arrangement consisting of layered silicate sheets.
(B) open framework structure featuring large channels and cavities.
(C) dense, tightly packed arrangement of atoms in the crystal lattice.
(D) silicate framework constructed primarily of single-chain units.

29. What is the fundamental difference in the silicate structure between the pyroxene group and the amphibole group?

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(A) Pyroxenes are sorosilicates, while amphiboles are cyclosilicates.
(B) Pyroxenes are sheet silicates, while amphiboles are framework silicates.
(C) Pyroxenes are single-chain silicates, while amphiboles are double-chain silicates.
(D) Pyroxenes are nesosilicates, while amphiboles are inosilicates.

30. Which of the following minerals belongs to the feldspathoid group?
(A) Orthoclase
(B) Albite
(C) Anorthite
(D) Nepheline

31. The characteristic cleavage of the amphibole group, at approximately 56° and 124°, is a direct consequence of its:
(A) double-chain silicate structure.
(B) framework silicate structure.
(C) single-chain silicate structure.
(D) sheet silicate structure.

32. The mica group of minerals, such as muscovite and biotite, exhibits perfect basal cleavage. This property is best explained by:
(A) their framework silicate structure.
(B) strong bonds within silicate sheets and weak forces between them.
(C) the presence of double chains of silica tetrahedra.
(D) their crystallization in the isometric system.

33. Consider the following statements about feldspar minerals:
1. They are framework silicates.
2. The group is divided into alkali feldspars and plagioclase feldspars.
3. They are the most abundant mineral group in the Earth's crust.

Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

34. A geologist finds a light-colored, glassy mineral in a silica-undersaturated volcanic rock. It does not show cleavage and is identified as a feldspathoid. Which of the following minerals is the most likely candidate?
(A) Leucite
(B) Quartz
(C) Hornblende
(D) Sanidine

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35. The presence of the hydroxyl radical (OH) is a defining chemical characteristic of which mineral group?
(A) Feldspar
(B) Feldspathoid
(C) Amphibole
(D) Pyroxene

36. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : Feldspathoids and quartz do not occur together in igneous rocks.
Reason (R) : Feldspathoids are silica-undersaturated minerals, and any excess silica would react with them to form feldspars.
Which of the following is correct?
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

37. Which of the following is NOT a member of the pyroxene group?
(A) Augite
(B) Diopside
(C) Hornblende
(D) Enstatite

38. Consider the following statements:
Statement I : All pyroxenes are single-chain inosilicates.
Statement II : All amphiboles contain essential structural hydroxyl (OH).
Which of the above statement(s) is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

39. Match List I with List II and select the correct answer using the codes given below:

List I: (Mineral Group)
P. Feldspar
Q. Pyroxene
R. Mica
S. Zeolite
List II: (Key Structural/Chemical Feature)
1. Single chain silicate, Si:O = 1:3
2. Framework silicate with channels containing water
3. Framework silicate, $(Al, Si)\ O_2$ framework
4. Sheet silicate, perfect basal cleavage
Codes:
(A) P-1, Q-3, R-2, S-4
(B) P-3, Q-1, R-4, S-2
(C) P-4, Q-2, R-1, S-3
(D) P-3, Q-4, R-2, S-1

40. Which property is characteristic of the mica group minerals due to their atomic structure?
(A) Perfect basal cleavage
(B) High hardness
(C) Conchoidal fracture
(D) Prismatic cleavage at 90°

41. What is the key difference in chemical composition between feldspars and feldspathoids?
(A) Feldspathoids contain more aluminum.
(B) Feldspathoids are hydrous.
(C) Feldspathoids are deficient in silica.
(D) Feldspathoids contain more alkali metals.

42. The substitution of $Na^{+}Si^{4+}$ by $Ca^{2+}Al^{3+}$ is characteristic of the solid solution series in:
(A) plagioclase feldspars.
(B) alkali feldspars.
(C) pyroxenes.
(D) micas.

43. Which of the following statements about the zeolite group is incorrect?
(A) They are framework silicates.
(B) They have a very open structure with large cavities.
(C) They are known for their ion-exchange capabilities.
(D) They are anhydrous silicates.

44. Augite is a common rock-forming mineral belonging to which group?
(A) Amphibole
(B) Pyroxene
(C) Feldspar
(D) Mica

45. The general formula for the amphibole group is complex, but all its members are characterized by the presence of a double chain of silica tetrahedra and:
(A) a complete lack of aluminum.
(B) essential molecular water (H_2O).
(C) the hydroxyl (OH) radical.
(D) the carbonate (CO_3) radical.

46. Which pair represents an isomorphous series within the feldspar group?
(A) Quartz and Cristobalite
(B) Calcite and Aragonite
(C) Muscovite and Biotite
(D) Albite and Anorthite

47. A rock is described as containing nepheline, leucite, and sodalite. This mineral assemblage indicates that the parent magma was:
(A) silica-undersaturated.
(B) silica-oversaturated.
(C) silica-saturated.
(D) peralkaline.

48. The crystal structure of pyroxenes consists of single chains of silica tetrahedra linked by cations. This results in how many directions of cleavage?
(A) One perfect direction
(B) Two directions at ~90 degrees
(C) Two directions at ~120 degrees
(D) Three directions at 90 degrees

49. Which of these minerals is a potassium-rich alkali feldspar?
(A) Albite
(B) Orthoclase
(C) Anorthite
(D) Labradorite

50. Based on their silicate structure, zeolites are classified as:
(A) Tectosilicates
(B) Inosilicates
(C) Phyllosilicates
(D) Nesosilicates

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51. The primary distinction between biotite and muscovite mica is the presence of significant amounts of which elements in biotite?
(A) Sodium and Calcium
(B) Aluminum and Silicon
(C) Iron and Magnesium
(D) Potassium and Water

52. What is the Si:O ratio in the double chains of the amphibole group?
(A) 1:3
(B) 2:5
(C) 1:2
(D) 4:11

53. Which of the following is a key physical property used to distinguish pyroxenes from amphiboles in hand specimen?
(A) Luster
(B) Color
(C) Cleavage angle
(D) Hardness

54. The mineral group characterized by a framework of $(Al, Si)\ O_2$ and considered the most abundant in the Earth's crust is:
(A) Pyroxene
(B) Feldspar
(C) Amphibole
(D) Mica

55. The term 'perthite' refers to an intergrowth texture resulting from exsolution in which mineral group?
(A) Pyroxenes
(B) Plagioclase feldspars
(C) Amphiboles
(D) Alkali feldspars

56. Which of the following statements is true for all minerals of the feldspathoid group?
(A) They crystallize from silica-deficient magmas.
(B) They are found in association with quartz.
(C) They are hydrous silicates.
(D) They exhibit perfect basal cleavage.

57. The structure of the mica group is best described as:
(A) single chains of silica tetrahedra.
(B) a three-dimensional framework of silica tetrahedra.
(C) sheets of silica tetrahedra bonded by layers of cations.
(D) isolated silica tetrahedra bonded by cations.

58. Which mineral is the sodium end-member of the plagioclase feldspar series?
(A) Albite
(B) Anorthite
(C) Orthoclase
(D) Sanidine

59. The characteristic optical property of the feldspar group is that they are all:
(A) Isotropic
(B) Uniaxial positive
(C) Uniaxial negative
(D) Biaxial

60. Which of the following is an example of a zeolite mineral?
(A) Augite
(B) Natrolite
(C) Hornblende
(D) Sodalite

61. The garnet group of minerals are nesosilicates with a general formula $X_3 Y_2 (SiO_4)_3$. The X and Y sites are occupied by:
(A) X = monovalent cations, Y = trivalent cations
(B) X = trivalent cations, Y = divalent cations
(C) X = divalent cations, Y = trivalent cations
(D) X = silicon, Y = aluminum

62. Kyanite, sillimanite, and andalusite are polymorphs of Al_2SiO_5. Their stability is primarily dependent on:
(A) the presence of water.
(B) the bulk chemical composition of the host rock.
(C) the rate of cooling.
(D) temperature and pressure.

63. Consider the following statements about quartz:
1. It is a framework silicate with the formula SiO_2.
2. It exhibits conchoidal fracture due to the absence of cleavage.
3. Varieties like amethyst and citrine are due to trace element impurities.

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Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

64. Which of the following is NOT a variety of quartz?
(A) Amethyst
(B) Olivine
(C) Citrine
(D) Rose Quartz

65. The mineral olivine is a solid solution series between which two end members?
(A) Albite and Anorthite
(B) Fayalite and Forsterite
(C) Enstatite and Ferrosilite
(D) Almandine and Pyrope

66. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : Garnets are commonly used as index minerals in metamorphic petrology.
Reason (R) : The chemical composition of garnet changes systematically with increasing grade of metamorphism.
Which of the following is correct?
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

67. Which of the following minerals belongs to the olivine group?
(A) Zircon
(B) Epidote
(C) Forsterite
(D) Staurolite

68. The chlorite group of minerals are structurally and chemically similar to:
(A) quartz.
(B) feldspars.
(C) pyroxenes.
(D) micas.

69. Match List I with List II and select the correct answer using the codes given below:
List I: (Al_2SiO_5 Polymorph)
P. Kyanite
Q. Andalusite
R. Sillimanite
S. Triple point coexisting
List II: (Characteristic Pressure/Temperature Stability)
1. High Temperature, Variable Pressure
2. Low Temperature, Low-to-Medium Pressure
3. High Pressure, Variable Temperature
4. Triple Point
Codes:
(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-2, R-1, S-4
(C) P-2, Q-3, R-1, S-4
(D) P-3, Q-1, R-2, S-4

70. Which of the following statements about the epidote group is incorrect?
(A) They are sorosilicates containing both isolated and paired silica tetrahedra.
(B) They are framework silicates common in silica-undersaturated rocks.
(C) Epidote itself is characterized by a distinctive pistachio-green color.
(D) The group includes minerals like zoisite and clinozoisite.

71. A precious stone is distinguished from a semi-precious stone primarily based on:
(A) its chemical composition.
(B) its crystal structure.
(C) its geological occurrence.
(D) rarity, durability, and beauty.

72. Arrange the following precious stones in decreasing order of their hardness on the Mohs scale:
1. Diamond
2. Corundum (Ruby/Sapphire)
3. Topaz
4. Quartz (Amethyst)
Select the correct answer using the code given below:
(A) 1, 2, 3, 4
(B) 2, 1, 3, 4
(C) 1, 3, 2, 4
(D) 4, 3, 2, 1

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73. The characteristic bottle-green to yellowish-green color of olivine is due to the presence of:
(A) aluminum.
(B) potassium.
(C) iron.
(D) calcium.

74. Which of the following aluminosilicate polymorphs is indicative of a high-pressure metamorphic environment?
(A) Kyanite
(B) Andalusite
(C) Sillimanite
(D) Cordierite

75. Based on silicate structure, the garnet group is classified as:
(A) Inosilicates (single chains).
(B) Phyllosilicates (sheets).
(C) Tectosilicates (framework).
(D) Nesosilicates (isolated tetrahedra).

76. Consider the following statements regarding mineral structures:
Statement I : The olivine structure consists of isolated SiO_4 tetrahedra linked by divalent cations.
Statement II : The chlorite group minerals are sheet silicates often formed by the alteration of ferromagnesian minerals.
Which of the above statement(s) is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

77. The term gem" or precious stone" is applied to a mineral primarily due to its:
(A) chemical formula.
(B) specific gravity.
(C) economic value derived from beauty and durability.
(D) mode of occurrence in igneous rocks.

78. Which of the following mineral pairs is NOT correctly matched with its group?
(A) Almandine - Garnet Group
(B) Fayalite - Olivine Group
(C) Clinozoisite - Epidote Group
(D) Sillimanite - Quartz Group

79. The lack of cleavage in quartz is best explained by:
(A) the uniform strength of Si-O bonds throughout its framework structure.
(B) its low hardness.
(C) its hexagonal crystal system.
(D) the presence of water in its crystal lattice.

80. What is the silicate structure of the epidote group minerals?
(A) Nesosilicate
(B) Sorosilicate
(C) Inosilicate
(D) Phyllosilicate

81. Which of the following best describes the atomic structure of chlorite?
(A) It consists of a framework composed of silica tetrahedra.
(B) It has alternating layers of mica-like and brucite-like sheets.
(C) It features double chains constructed of silica tetrahedra.
(D) It is composed mainly of isolated silica tetrahedral units.

82. Andalusite, an Al_2SiO_5 polymorph, is typically formed under conditions of:
(A) low pressure and moderate to high temperature.
(B) high pressure and high temperature.
(C) high pressure and low temperature.
(D) extremely low temperature regardless of pressure.

83. Which property is common to all three aluminosilicate polymorphs: kyanite, andalusite, and sillimanite?
(A) Same crystal system
(B) Same hardness
(C) Same chemical formula
(D) Same cleavage

84. Ruby (red) and Sapphire (blue) are gem varieties of which mineral?
(A) Beryl
(B) Quartz
(C) Topaz
(D) Corundum

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85. A hand sample of a mineral shows a dodecahedral crystal form, a glassy luster, and no cleavage. It is quite hard. Which mineral group is it most likely from?
(A) Feldspar
(B) Olivine
(C) Garnet
(D) Mica

86. The magnesium-rich end member of the olivine solid-solution series is:
(A) Fayalite (Fe_2SiO_4).
(B) Forsterite (Mg_2SiO_4).
(C) Ferrosilite ($FeSiO_3$).
(D) Enstatite ($MgSiO_3$).

87. Which of the following is considered a semi-precious stone?
(A) Diamond
(B) Ruby
(C) Emerald
(D) Amethyst

88. The mineral sillimanite, a polymorph of Al_2SiO_5 , is stable under conditions of:
(A) high temperature.
(B) high pressure.
(C) low temperature.
(D) low pressure.

89. Which of the following statements about the olivine group is incorrect?
(A) Olivine minerals are nesosilicates.
(B) They form a complete solid solution series between forsterite and fayalite.
(C) They are common in felsic igneous rocks like granite.
(D) They typically have a high specific gravity and a glassy luster.

90. Chlorite is a common product of low-grade metamorphism or hydrothermal alteration of which minerals?
(A) Pyroxenes, amphiboles, and biotite
(B) Quartz and feldspar
(C) Calcite and dolomite
(D) Kyanite and sillimanite

91. Double refraction is a phenomenon observed in:
(A) isotropic minerals only.
(B) all minerals, both isotropic and anisotropic.
(C) amorphous materials like glass only.
(D) anisotropic minerals only.

92. The Becke line test is a common laboratory method used for the determination of a mineral's:
(A) Birefringence.
(B) Refractive Index relative to the mounting medium.
(C) Pleochroism.
(D) Optic sign.

93. Consider the following statements regarding optical properties of minerals:
1. Isotropic minerals have a single refractive index.
2. Anisotropic minerals split a beam of light into two rays.
3. The phenomenon of double refraction is characteristic of all crystalline solids.

Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

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94. What is the definition of birefringence?
(A) The property of a mineral to show different colors in different crystallographic directions.
(B) The angle between the two optic axes in a biaxial mineral.
(C) The measure of a mineral's ability to bend light.
(D) The numerical difference between the highest and lowest refractive indices of an anisotropic mineral.

95. In optical mineralogy, a mineral that belongs to the isometric crystal system will be:
(A) Isotropic.
(B) Uniaxial.
(C) Biaxial.
(D) Pleochroic.

96. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : When an isotropic mineral is viewed under crossed polarizers, it remains dark (extinct) in all orientations.

Reason (R) : An isotropic mineral does not split the plane-polarized light from the polarizer into two rays, so no light can pass through the analyzer.
Which of the following is correct?
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

97. Which of the following statements about double refraction is correct?
(A) It occurs when light passes through an isotropic mineral.
(B) It involves splitting a single light ray into an ordinary ray (O-ray) and an extraordinary ray (E-ray).
(C) The O-ray and E-ray travel at the same velocity in all directions within the crystal.
(D) It is a property exclusive to minerals in the hexagonal system.

98. The optical classification of minerals divides them into which two primary groups?
(A) Isotropic and Anisotropic
(B) Uniaxial and Biaxial
(C) Positive and Negative
(D) Opaque and Non-opaque

99. Match List I with List II and select the correct answer using the codes given below:
List I: (Optical Property)
P. Refractive Index (RI)
Q. Birefringence
R. Pleochroism
S. Double Refraction
List II: (Description)
1. Splitting of a light ray into two components in an anisotropic mineral
2. Variation in color with crystallographic direction
3. Ratio of the speed of light in vacuum to its speed in a substance
4. The difference between the maximum and minimum refractive indices
Codes:
(A) P-3, Q-4, R-2, S-1
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-1, R-4, S-2
(D) P-4, Q-3, R-1, S-2

100. Which of the following is NOT a fundamental principle of optics relevant to mineralogy?
(A) Refraction
(B) Polarization
(C) Double refraction
(D) Radioactive decay

101. A mineral is rotated on a microscope stage under crossed polarizers and shows interference colors. This observation indicates that the mineral is:
(A) Isotropic.
(B) Opaque.
(C) Anisotropic.
(D) Amorphous.

102. The refractive index (n) of a mineral is a measure of:
(A) how much the mineral absorbs light.
(B) how much the speed of light is reduced as it passes through the mineral.
(C) the angle between its cleavage planes.
(D) the intensity of its interference colors.

103. Which of the following crystal systems contains minerals that are optically isotropic?
(A) Tetragonal
(B) Orthorhombic
(C) Monoclinic
(D) Isometric

104. When determining the refractive index of a mineral fragment using the immersion method, the Becke line moves into the medium with the higher refractive index when:
(A) the microscope stage is lowered or the focal distance is increased.
(B) the microscope stage is raised or the focal distance is decreased.
(C) the stage is rotated 90 degrees.
(D) the analyzer is removed from the light path.

105. Birefringence can be qualitatively estimated under the petrographic microscope by observing:
(A) the mineral's relief.
(B) the intensity of pleochroism.
(C) the order of interference colors.
(D) the extinction angle.

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106. What happens to a ray of unpolarized light when it passes through the lower polarizer of a petrographic microscope?
(A) It is constrained to vibrate in a single plane.
(B) It is split into two rays vibrating at right angles.
(C) It becomes circularly polarized.
(D) Its velocity is increased.

107. Consider the following statements regarding light rays in minerals:
Statement I : The ordinary ray (O-ray) obeys Snell's law of refraction.
Statement II : The extraordinary ray (E-ray) does not obey Snell's law of refraction as its velocity changes with direction.
Which of the above statement(s) is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

108. Anisotropic minerals are further subdivided into:
(A) positive and negative groups.
(B) uniaxial and biaxial groups.
(C) high relief and low relief groups.
(D) transparent and translucent groups.

109. Which of the following is an example of an isotropic mineral?
(A) Quartz
(B) Calcite
(C) Garnet
(D) Orthoclase

110. The property of double refraction is most famously and visibly demonstrated by clear crystals of:
(A) Quartz.
(B) Halite.
(C) Fluorite.
(D) Calcite (Iceland Spar).

111. The interference colors seen when viewing an anisotropic mineral under crossed polarizers are a direct function of the mineral's thickness and its:
(A) Birefringence.
(B) Refractive index.
(C) Density.
(D) Pleochroism.

112. Minerals belonging to the tetragonal and hexagonal crystal systems are optically:
(A) Isotropic.
(B) Uniaxial.
(C) Biaxial.
(D) Opaque.

113. Relief" in optical mineralogy refers to:
(A) the difference in color of a mineral in plane polarized light.
(B) the degree to which a mineral grain stands out from its mounting medium.
(C) the maximum interference color shown by a mineral.
(D) the sharpness of the extinction position.

114. If a mineral has a refractive index very close to that of the mounting medium (e.g., Canada Balsam), it will exhibit:
(A) low relief.
(B) high relief.
(C) strong pleochroism.
(D) high-order interference colors.

115. A mineral shows maximum birefringence when its vibration directions are oriented at what angle to the polarizer's vibration direction?
(A) 0°
(B) 30°
(C) 45°
(D) 90°

116. The phenomenon where a mineral remains dark under crossed polars is called:
(A) interference.
(B) pleochroism.
(C) refraction.
(D) extinction.

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117. What is the primary purpose of using immersion oils in the determination of refractive index?
(A) To increase the birefringence of the mineral.
(B) To lubricate the microscope stage.
(C) To provide a medium of known refractive index for comparison.
(D) To enhance the pleochroism of the mineral.

118. Which statement is incorrect regarding the optical properties of minerals?

(A) Isotropic minerals have the same light velocity in all directions.
(B) Birefringence is a property of isotropic minerals.
(C) Anisotropic minerals show different properties in different directions.
(D) Minerals of the isometric system are isotropic.

119. Double refraction is the splitting of light into two rays that are:
(A) polarized parallel to each other.
(B) polarized at 45 degrees to each other.
(C) unpolarized.
(D) polarized at right angles to each other.

120. A mineralogist uses a Michel-Lévy chart to determine the thickness of a mineral section or its birefringence if one of these two is known. What is the third variable on the chart?
(A) Interference color
(B) Refractive index
(C) Optic angle (2V)
(D) Extinction angle

121. In Goldschmidt's geochemical classification of elements, elements that have a strong affinity for sulfur and are concentrated in the Earth's core are called:
(A) Lithophile.
(B) Siderophile.
(C) Chalcophile.
(D) Atmophile.

122. The radioactive decay of Rubidium-87 (^{87}Rb) to Strontium-87 (^{87}Sr) occurs through which process?
(A) Beta decay
(B) Alpha decay
(C) Electron capture
(D) Gamma emission

123. Consider the following statements about geochemical cycles:
1. A geochemical cycle describes the pathways of elements within the Earth.
2. The rock cycle is a fundamental component of geochemical cycles for many elements.
3. Human activities cannot influence geochemical cycles.

Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

124. What are the two most abundant elements in the Earth's crust by weight?
(A) Silicon and Aluminum
(B) Oxygen and Silicon
(C) Iron and Oxygen
(D) Iron and Nickel

125. The First Law of Thermodynamics, as applied to geochemical systems, is a statement of:
(A) the tendency towards increasing entropy.
(B) the impossibility of reaching absolute zero.
(C) the conservation of energy.
(D) the equilibrium state of a system.

126. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : The K-Ar dating method is particularly useful for dating young volcanic rocks.
Reason (R) : Argon is a noble gas that can easily escape from a rock if it is reheated, effectively resetting the radiometric clock.
Which of the following is correct?
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

127. In the geochemical classification of elements, 'Lithophile' elements are those that:
(A) are 'rock-loving' and concentrate in the silicate crust.
(B) are 'iron-loving' and concentrate in the core.
(C) are 'gas-loving' and occur in the atmosphere.
(D) are 'sulfur-loving' and form sulfide ores.

128. Which of the following radioactive decay schemes is a series of decays rather than a single step?
(A) Rb-Sr
(B) U-Pb
(C) K-Ar
(D) Sm-Nd

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129. The geochemical cycle describes the:
(A) movement and transformation of chemical elements through the Earth's spheres.
(B) formation of different rock types in a specific sequence.
(C) daily and seasonal variations in atmospheric composition.
(D) process of crystallization of minerals from a magma.

130. According to the laws of thermodynamics, a spontaneous geochemical reaction will always proceed in a direction that:
(A) increases the total energy of the system.
(B) decreases the total entropy of the universe.
(C) leads to a decrease in the Gibbs Free Energy of the system.
(D) consumes the maximum amount of heat.

131. Arrange the following layers of the Earth from the center outwards:
1. Crust
2. Inner Core
3. Mantle
4. Outer Core

Select the correct answer using the code given below:
(A) 2, 4, 3, 1
(B) 4, 2, 3, 1
(C) 1, 3, 4, 2
(D) 2, 3, 4, 1

132. The radioactive isotope Potassium-40 (^{40}K) decays to Argon-40 (^{40}Ar) by which process?
(A) Alpha decay
(B) Beta decay
(C) Electron capture
(D) Nuclear fission

133. Which element group in Goldschmidt's classification includes volatile elements like H, N, and the noble gases?
(A) Lithophile
(B) Atmophile
(C) Siderophile
(D) Chalcophile

134. The U-Pb dating method often uses which mineral because it incorporates uranium into its structure but excludes lead upon crystallization?
(A) Calcite
(B) Olivine
(C) Halite
(D) Zircon

135. Which statement regarding the geochemical composition of the Earth is correct?
(A) The core is predominantly composed of iron and nickel.
(B) The crust and the mantle have identical chemical compositions.
(C) The entire Earth has the same composition as the crust.
(D) Silicon is the most abundant element in the Earth as a whole.

136. The decay of Samarium-147 (^{147}Sm) to Neodymium-143 (^{143}Nd) is an example of:
(A) Beta decay.
(B) Electron capture.
(C) Alpha decay.
(D) Gamma emission.

137. The Second Law of Thermodynamics implies that natural processes tend to move towards a state of:
(A) minimum order and maximum entropy.
(B) maximum energy and minimum entropy.
(C) minimum energy and minimum entropy.
(D) maximum order and minimum entropy.

138. Which of the following pairs of element and its geochemical classification is incorrectly matched?
(A) O - Lithophile
(B) Fe - Siderophile
(C) S - Chalcophile
(D) Au - Atmophile

139. What is a key assumption in Rb-Sr geochronology?
(A) The rock contained no strontium when it formed.
(B) The rock has remained a closed system with respect to Rb and Sr since its formation.
(C) The rate of decay of Rb has varied over geologic time.
(D) All strontium in the rock is radiogenic.

140. The concept of the geochemical cycle is essential for understanding:
(A) only the formation of ore deposits.

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(B) only the radioactive decay of elements.
(C) the distribution and concentration of elements in the Earth systems.
(D) the optical properties of minerals.

141. Compared to the Earth's crust, the mantle is significantly enriched in:
(A) Silicon and Aluminum.
(B) Sodium and Potassium.
(C) Carbon and Sulfur.
(D) Iron and Magnesium.

142. Which radioactive decay system involves a parent isotope from the rare earth elements?
(A) Sm-Nd
(B) U-Pb
(C) K-Ar
(D) Rb-Sr

143. The 'siderophile' elements are so named because they are:
(A) 'rock-loving'.
(B) 'iron-loving'.
(C) 'sulfur-loving'.
(D) 'gas-loving'.

144. What does the term 'half-life' signify in a radioactive decay scheme?
(A) Half the total age of the sample being dated.
(B) The time it takes for half of the parent atoms to decay.
(C) The time it takes for the daughter product to become stable.
(D) The time when the decay process is half-finished.

145. A system that can exchange both energy and matter with its surroundings is called:
(A) an open system.
(B) an isolated system.
(C) a closed system.
(D) an adiabatic system.

146. Gold (Au), Platinum (Pt), and other precious metals that tend to alloy with iron are classified as:
(A) Lithophile.
(B) Siderophile.
(C) Chalcophile.
(D) Atmophile.

147. The concept of a geochemical cycle integrates principles from geology, chemistry, and:
(A) physics.
(B) astronomy.
(C) mathematics.
(D) biology.

148. The overall geochemical composition of the Earth is inferred primarily from the study of meteorites, particularly:
(A) iron meteorites.
(B) stony-iron meteorites.
(C) carbonaceous chondrites.
(D) achondrites.

149. Which of the following is a fundamental law of thermodynamics?
(A) The law of superposition.
(B) The law of conservation of energy.
(C) The law of faunal succession.
(D) The law of universal gravitation.

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150. Which of the following is NOT a sulfide mineral?
(A) Galena (PbS)
(B) Sphalerite (ZnS)
(C) Pyrite (FeS_2)
(D) Magnetite (Fe_3O_4)

151. Consider the following statements regarding mineralogical phenomena:
Statement I : Isomorphism allows for the formation of solid solution series in minerals.
Statement II : Polymorphism involves minerals with identical chemistry but different crystal structures.
Which of the above statement(s) is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

152. Consider the following characteristics of a mineral group:
1. They are anhydrous carbonates.
2. They crystallize in the orthorhombic system.
3. Aragonite is the principal member.

Which mineral group is described by the statements above?
(A) Calcite group
(B) Dolomite group
(C) Aragonite group

(D) Hydrous carbonates

153. What is the Si:O ratio in a nesosilicate (isolated tetrahedra) structure like olivine?
(A) 1:4
(B) 1:2
(C) 1:3
(D) 2:7

154. The unmixing of a high-temperature alkali feldspar into sodium-rich and potassium-rich lamellae upon cooling is an example of:
(A) polymorphism.
(B) isomorphism.
(C) recrystallization.
(D) exsolution.

155. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : Minerals of the calcite group exhibit perfect rhombohedral cleavage.
Reason (R) : The bonding strength is significantly weaker along the rhombohedral planes in their trigonal crystal structure.
Which of the following is correct?
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

156. Which oxide mineral group has the general formula XY2O_4 and includes minerals like magnetite and chromite?
(A) Rutile group (XO_2)
(B) Periclase group (X_O)
(C) Spinel group (XY_2O_4)
(D) Hematite group (X_2O_3)

157. The difference between anhydrous and hydrous sulfates is the presence of what in the crystal structure of hydrous sulfates?
(A) Hydroxyl ions (OH-)
(B) Carbonate ions (CO_3^{2-})
(C) Silicon tetrahedra (SiO_4)
(D) Molecular water (H_2O)

158. Match List I with List II and select the correct answer using the codes given below:
List I: (Mineral)
P. Galena
Q. Pyrite
R. Chalcocite
S. Sphalerite
List II: (Sulfide Structural Type)
1. AX2
2. A2X
3. AX
4. AX
Codes:
(A) P-3, Q-1, R-2, S-4
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-2, R-1, S-4
(D) P-4, Q-3, R-2, S-1

159. Which of the following is a key characteristic of the dolomite group carbonates?
(A) They are all simple carbonates of a single metal (e.g., $CaCO_3$).
(B) They are double carbonates with two different cation sites.
(C) They crystallize in the orthorhombic system.
(D) They are typically found in igneous rocks.

160. Based on the classification of silicate structures, minerals with a Si:O ratio of 2:5 (or Si_4O_{10}) belong to which group?
(A) Phyllosilicates (Sheets)
(B) Inosilicates (Chains)
(C) Tectosilicates (Frameworks)
(D) Nesosilicates (Isolated)

161. A geologist identifies a perthitic texture in a feldspar crystal. This observation implies that the mineral is most likely an:
(A) alkali feldspar that cooled slowly.
(B) anorthite that cooled rapidly.
(C) albite that experienced high pressure.
(D) anorthoclase that was hydrothermally altered.

162. The primary reason feldspathoids are found in silica-undersaturated rocks is that:
(A) they require high pressures to form, which are only found in undersaturated magmas.
(B) they are hydrous minerals that require a water-rich magma.
(C) they are unstable in the presence of free silica (quartz).
(D) they contain more iron and magnesium

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than feldspars.

163. The presence of hydroxyl (OH) ions in the crystal lattice is a defining chemical feature of all members of which mineral group?
(A) Pyroxene
(B) Feldspar
(C) Feldspathoid
(D) Amphibole

164. The cleavage of pyroxenes (approx. 90°) and amphiboles (approx. 120°/60°) is a direct reflection of their internal:
(A) chemical bonding with cations.
(B) density and specific gravity.
(C) arrangement of silica tetrahedra into chains.
(D) optical properties.

165. A student observes a mineral with perfect basal cleavage, splitting easily into thin, flexible sheets. This mineral most likely belongs to the:
(A) feldspar group.
(B) mica group.
(C) pyroxene group.
(D) zeolite group.

166. Which of the following properties is characteristic of the zeolite mineral group?
(A) High density and metallic luster.
(B) Occurrence in silica-oversaturated granites.
(C) A rigid framework structure that prevents ion exchange.
(D) An open framework structure that allows for reversible dehydration.

167. Which of these mineral pairs correctly represents the end-members of the plagioclase feldspar series?
(A) Albite and Anorthite
(B) Orthoclase and Sanidine
(C) Nepheline and Leucite
(D) Muscovite and Biotite

168. What is the fundamental structural unit of pyroxene minerals?
(A) A three-dimensional framework of SiO_2.
(B) A double chain of silica tetrahedra.
(C) A single chain of silica tetrahedra.
(D) A sheet of silica tetrahedra.

169. Which statement incorrectly describes the feldspar group?
(A) They are all chemically simple, with no solid solution.
(B) They are the most abundant minerals in the Earth's crust.
(C) They are classified as tectosilicates.
(D) The group is divided into alkali feldspars and plagioclase feldspars.

170. A mineral that commonly forms in silica-deficient, alkali-rich igneous rocks and is considered a feldspar-analogue is a:
(A) pyroxene.
(B) mica.
(C) garnet.
(D) feldspathoid.

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171. The main chemical difference between the dark mica (biotite) and the light mica (muscovite) is the presence of which elements in biotite?
(A) Sodium and Calcium
(B) Iron and Magnesium
(C) Silicon and Oxygen
(D) Potassium and Aluminum

172. The Garnet mineral group belongs to which class of silicates?
(A) Sorosilicates
(B) Inosilicates
(C) Nesosilicates
(D) Phyllosilicates

173. The triple point of the Al_2SiO_5 system refers to the specific pressure-temperature conditions where:
(A) all three polymorphs melt.
(B) the aluminosilicate minerals break down into corundum and quartz.
(C) only two of the three polymorphs can coexist.
(D) kyanite, andalusite, and sillimanite can all exist in stable equilibrium.

174. Which statement accurately describes the olivine group of minerals?
(A) They are nesosilicates forming a solid solution series between forsterite and fayalite.
(B) They are double-chain silicates common in granites.

(C) They exhibit perfect basal cleavage and are very soft.
(D) They are typically found in association with quartz.

175. Which of the following is NOT a variety of quartz?
(A) Smoky Quartz
(B) Green Garnet
(C) Rose Quartz
(D) Tiger's Eye

176. The epidote group minerals are classified as sorosilicates because their structure contains:
(A) only isolated (SiO_4) tetrahedra.
(B) both isolated (SiO_4) and paired (Si_2O_7) tetrahedral groups.
(C) only single chains of tetrahedra.
(D) only continuous sheets of tetrahedra.

177. Chlorite is a common mineral in low-grade metamorphic rocks and is characterized by its:
(A) green color and platy habit.
(B) extreme hardness and red color.
(C) cubic crystals and salty taste.
(D) conchoidal fracture and glassy luster.

178. A mineral described as a precious stone" must possess which of the following qualities?
(A) High radioactivity
(B) Low specific gravity
(C) Beauty, durability, and rarity
(D) A simple chemical formula

179. The aluminosilicate polymorph that is stable at high pressures and is often bladed and blue is:
(A) Sillimanite.
(B) Andalusite.
(C) Cordierite.
(D) Kyanite.

180. Emerald is the precious green variety of which mineral?
(A) Corundum
(B) Topaz
(C) Beryl
(D) Tourmaline

181. A mineral showing high relief, no cleavage, granular texture, and a characteristic bottle-green color is most likely:
(A) Hornblende.
(B) Olivine.
(C) Augite.
(D) Epidote.

182. Consider the following statements about aluminosilicates:
1. Kyanite, andalusite, and sillimanite have the same chemical formula, Al_2SiO_5.
2. Their presence in a metamorphic rock can indicate the pressure-temperature conditions of its formation.
3. Sillimanite is the low-pressure polymorph.
Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

183. When a mineralogist refers to the 'optical classification' of a mineral, they are primarily distinguishing between:
(A) isotropic and anisotropic minerals.
(B) transparent and opaque minerals.
(C) uniaxial and biaxial minerals.
(D) high-relief and low-relief minerals.

184. The property of an anisotropic mineral that causes it to split a beam of plane-polarized light into two mutually perpendicular, plane-polarized components is called:
(A) absorption.
(B) pleochroism.
(C) double refraction.
(D) dispersion.

185. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : Minerals belonging to the isometric crystal system are optically isotropic.
Reason (R) : Due to the high degree of symmetry, the velocity of light is the same in all crystallographic directions within an isometric mineral.
Which of the following is correct?
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.

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(D) A is false but R is true.

186. In the context of optical mineralogy, what does birefringence quantify?
(A) The absolute refractive index of a mineral.
(B) The angle of rotation of polarized light.
(C) The amount of light absorbed by a mineral.
(D) The maximum difference in refractive indices within an anisotropic mineral.

187. Which method is most commonly used in a laboratory to determine the refractive index of a mineral grain?
(A) The spectrometer method
(B) The immersion method using the Becke line
(C) The prism method
(D) X-ray diffraction

188. Match List I with List II and select the correct answer using the codes given below:
List I: (Crystal System)
P. Isometric
Q. Tetragonal
R. Orthorhombic
S. Hexagonal
List II: (Optical Character)
1. Biaxial
2. Uniaxial
3. Isotropic
4. Uniaxial
Codes:
(A) P-3, Q-2, R-1, S-4
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-1, R-4, S-2
(D) P-4, Q-3, R-2, S-1

189. Which of the following phenomena would NOT be observed when viewing an isotropic mineral under a polarizing microscope with both polars inserted?
(A) The mineral remains extinct upon rotation.
(B) The mineral appears dark.
(C) The mineral grain shows its true color (if any).
(D) Interference colors.

190. A key principle of optics applied in petrography is that light bends or 'refracts' when it passes from one medium to another with a different:
(A) refractive index.
(B) temperature.
(C) density.
(D) chemical composition.

191. Arrange the following steps for determining the relative refractive index using the Becke line method in the correct order:
1. Observe the bright line (Becke line) around the grain boundary.
2. Bring the mineral grain into sharp focus.
3. Lower the microscope stage.
4. Note the direction in which the Becke line moves (into the grain or into the oil).

Select the correct answer using the code given below:
(A) 2, 1, 3, 4
(B) 1, 2, 3, 4
(C) 2, 3, 1, 4
(D) 3, 2, 1, 4

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192. The geochemical classification of elements proposed by V.M. Goldschmidt is based on their:
(A) atomic weight and number.
(B) distribution among the phases of meteorite systems (metal, sulfide, silicate).
(C) melting point and boiling point.
(D) mode of occurrence in sedimentary rocks.

193. The radioactive decay scheme of ^{238}U to ^{206}Pb is known as a decay series because it involves:
(A) multiple sequential alpha and beta decay events.
(B) a single beta decay.
(C) a single alpha decay.
(D) only electron capture.

194. Consider the following statements regarding the Earth's composition:
Statement I : The Earth's core is believed to be composed primarily of lithophile elements.
Statement II : The Earth's crust is dominated by the elements oxygen and silicon.
Which of the above statement(s) is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

195. The law of thermodynamics that states that the entropy of an isolated system always increases over time is the:
(A) First Law.

(B) isotropic.
(C) uniaxial.
(D) opaque.

264. What fundamental principle of optics is responsible for the 'bending' of light as it passes from air into a mineral?
(A) Reflection
(B) Diffraction
(C) Refraction
(D) Polarization

265. In Goldschmidt's classification, lead (Pb) shows affinity for both oxygen and sulfur. It is therefore classified as:
(A) Chalcophile.
(B) Lithophile.
(C) Siderophile.
(D) both Lithophile and Chalcophile.

266. A concordia diagram is a graphical tool used in which radiometric dating method?
(A) K-Ar
(B) Rb-Sr
(C) Sm-Nd
(D) U-Pb

267. The concept that natural processes tend to increase the total disorder, or entropy, of the universe is a statement of the:
(A) First Law of Thermodynamics.
(B) Second Law of Thermodynamics.
(C) Third Law of Thermodynamics.
(D) Law of Geochemical Cycles.

268. A geologist studies the flow of phosphorus from rocks to soil, into plants, and eventually into the ocean. This study is focused on a:
(A) radioactive decay scheme.
(B) polymorphic transformation.
(C) geochemical cycle.
(D) solid solution series.

269. Compared to the bulk Earth, the crust is significantly enriched in:
(A) Iron and Nickel.
(B) Magnesium.
(C) Siderophile elements.
(D) Lithophile elements like Si, Al, K, and Na.

270. An isochron diagram in Rb-Sr dating is a plot of:
(A) $^{87}Rb/^{86}Sr$ vs. $^{87}Sr/^{86}Sr$.
(B) $^{87}Sr/^{86}Sr$ vs. time.
(C) ^{87}Rb vs. ^{87}Sr.
(D) time vs. temperature.

271. In Goldschmidt's classification, which group of elements is 'gas-loving' and concentrated in the atmosphere and hydrosphere?
(A) Lithophile
(B) Atmophile
(C) Siderophile
(D) Chalcophile

272. Consider the following statements regarding radioactive decay:
1. An alpha decay decreases the atomic mass by 4 and atomic number by 2.
2. A beta decay does not change the atomic mass and increases the atomic number by 1.
3. Electron capture does not change the atomic mass and decreases the atomic number by 1.

Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

273. The high concentration of iron and nickel in the Earth's core is evidence for the abundance of which class of elements during Earth's formation?
(A) Siderophile
(B) Lithophile
(C) Chalcophile
(D) Atmophile

274. A mineral that has the same chemical composition as another but a different crystal structure is known as a:
(A) Isomorph.
(B) Pseudomorph.
(C) Polymorph.
(D) Phenocryst.

275. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : Zeolites are widely used as water softeners and industrial catalysts.
Reason (R) : Their open framework structure contains channels and cavities that can trap

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(C) XO_2 type oxides
(D) $XY2O_4$ type oxides

209. The substitution of Ca^{2+} for Na^{+} in the plagioclase series requires a concurrent substitution to maintain charge balance. What is this coupled substitution?
(A) Al^{3+} for Si^{4+}
(B) Si^{4+} for Al^{3+}
(C) K^{+} for Ca^{2+}
(D) Mg^{2+} for Fe^{2+}

210. Which mineral group is characterized by a three-dimensional linkage of silica tetrahedra, resulting in a Si:O ratio of 1:2?
(A) Micas
(B) Pyroxenes
(C) Feldspars and Quartz
(D) Olivines

211. What is the key structural feature of the zeolite group that gives them their unique properties of ion exchange and reversible dehydration?
(A) A layered structure with weak interlayer bonds.
(B) A structure composed of isolated silica tetrahedra.
(C) A dense structure with no room for water molecules.
(D) A framework structure with large channels and cavities.

212. Consider the following statements about mica group minerals:
1. They are phyllosilicates, or sheet silicates.
2. They exhibit perfect basal cleavage.
3. Biotite is an iron and magnesium-rich mica.
Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

213. The absence of quartz in a rock containing nepheline is best explained by:
(A) the principle of polymorphism.
(B) a chemical incompatibility due to silica saturation levels.
(C) the different melting points of the two minerals.
(D) the different crystal systems of the two minerals.

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214. A mineralogist identifies augite in a rock thin section. To which major rock-forming mineral group does augite belong?
(A) Amphibole
(B) Feldspar
(C) Olivine
(D) Pyroxene

215. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : Amphiboles have a more complex chemical formula than pyroxenes.
Reason (R) : In addition to the compositional variations seen in pyroxenes, amphiboles contain an essential hydroxyl (OH) group and have more varied cation substitution sites.
Which of the following is correct?
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

216. Which of the following minerals is a nesosilicate?
(A) Quartz
(B) Muscovite
(C) Garnet
(D) Augite

217. Sillimanite is a high-temperature polymorph of Al_2SiO_5. Its crystal habit is typically:
(A) fibrous or slender prismatic crystals.
(B) equant, dodecahedral crystals.
(C) bladed, blue crystals.
(D) square, prismatic crystals with a cross-shaped internal pattern.

218. Match List I with List II and select the correct answer using the codes given below:
List I: (Mineral)
P. Forsterite
Q. Almandine
R. Zoisite
S. Amethyst
List II: (Mineral Group)
1. Garnet Group
2. Quartz Group

(B) ratio of divalent to trivalent cations.
(C) hardness and specific gravity of the mineral.
(D) geological environment of formation.

242. Consider the following statements about mineral properties:
1. Isomorphism is the phenomenon of different minerals having the same crystal structure.
2. Polymorphism is the phenomenon of a single chemical compound existing in more than one crystal structure.
3. Exsolution is the process of a solid solution unmixing into distinct phases.

Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

243. Corundum (Al_2O_3) and Hematite (Fe_2O_3) are examples of which oxide type?
(A) XO
(B) XO_2
(C) X_2O_3
(D) XY_2O_4

244. Dolomite, $CaMg(CO_3)_2$, is best described as a:
(A) member of the calcite group.
(B) member of the aragonite group.
(C) double carbonate belonging to its own group.
(D) hydrous carbonate.

245. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : Pyroxenes and amphiboles can be distinguished by their cleavage angles.
Reason (R) : The difference in cleavage angles is a direct result of pyroxenes having a single-chain silicate structure and amphiboles having a double-chain structure.
Which of the following is correct?
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

246. The mineral nepheline, $(Na, K)AlSiO_4$, is a common:
(A) feldspar.
(B) zeolite.
(C) pyroxene.
(D) feldspathoid.

247. The basic structural unit of the mica group results in which characteristic physical property?
(A) Perfect basal cleavage
(B) Conchoidal fracture
(C) High hardness
(D) Adamantine luster

248. Match List I with List II and select the correct answer using the codes given below:
List I: (Silicate Structural Group)
P. Nesosilicate
Q. Inosilicate (single chain)
R. Phyllosilicate
S. Tectosilicate
List II: (Example Mineral Group)
1. Pyroxene
2. Feldspar
3. Olivine
4. Mica
Codes:
(A) P-3, Q-1, R-4, S-2
(B) P-1, Q-3, R-2, S-4
(C) P-3, Q-2, R-1, S-4
(D) P-4, Q-1, R-2, S-3

249. Which of the following is an alkali feldspar?
(A) Orthoclase
(B) Anorthite
(C) Bytownite
(D) Labradorite

250. The ability of zeolites to act as 'molecular sieves' is a consequence of their:
(A) specific mineralogical and chemical composition.
(B) characteristic high density and specific gravity.
(C) structural arrangement consisting of layered sheets.
(D) open framework featuring channels of a fixed size.

251. Arrange the following minerals in order of their typical sequence of crystallization from

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229. An anisotropic minerals are divided into uniaxial and biaxial groups based on:
(A) their chemical formula.
(B) the number of optic axes they possess.
(C) their crystal color.
(D) their cleavage patterns.

230. The geochemical classification of elements into lithophile, siderophile, chalcophile, and atmophile was proposed by:
(A) N. L. Bowen
(B) James Hutton
(C) A. E. Ringwood
(D) V. M. Goldschmidt

231. In the Rb-Sr decay scheme, what particle is emitted during the transformation of ^{87}Rb to ^{87}Sr?
(A) A beta particle (electron)
(B) An alpha particle
(C) A neutron
(D) A positron

232. Which layer of the Earth is chemically characterized by being a silicate-rich shell, but with more magnesium and iron than the crust?
(A) The inner core
(B) The outer core
(C) The mantle
(D) The asthenosphere

233. The concept of Gibbs Free Energy (G) is central to applying thermodynamics to geochemistry because a decrease in G indicates:
(A) the reaction is spontaneous under the given conditions.
(B) the reaction is non-spontaneous.
(C) the reaction is at equilibrium.
(D) the reaction absorbs heat from the surroundings.

234. The movement of carbon between the atmosphere, oceans, biosphere, and lithosphere is an example of a:
(A) radioactive decay scheme.
(B) polymorphic transformation.
(C) Bowen's reaction series.
(D) geochemical cycle.

235. The K-Ar dating method relies on the decay of ^{40}K to ^{40}Ar. What is a major potential problem with this method?
(A) Potassium is a very rare element in rocks.
(B) Loss of the daughter isotope, gaseous Argon, from the rock can lead to an erroneously young age.
(C) The half-life of 40K is too short for geological dating.
(D) Contamination by atmospheric Calcium-40.

236. Uranium and Thorium are typically classified as which type of element in the Goldschmidt scheme?
(A) Siderophile
(B) Chalcophile
(C) Lithophile
(D) Atmophile

237. What is the primary composition of the Earth's continental crust?
(A) Basaltic (mafic)
(B) Ultramafic
(C) Iron-Nickel alloy
(D) Granitic (felsic)

238. The decay of ^{147}Sm to ^{143}Nd involves the emission of:
(A) an alpha particle.
(B) a beta particle.
(C) a gamma ray.
(D) a positron.

239. The First Law of Thermodynamics is essentially a statement about the conservation of:
(A) mass.
(B) energy.
(C) momentum.
(D) charge.

240. Which sulfide mineral class is represented by Argentite (Ag_2S)?
(A) AX type
(B) A2X type
(C) AX2 type
(D) A3X2 type

241. The structural classification of silicates is based on the:
(A) way in which silica tetrahedra are linked together.

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(B) Third Law.
(C) Zeroth Law.
(D) Second Law.

196. Which of the following is a fundamental concept of the geochemical cycle?
(A) Elements are permanently locked into one reservoir.
(B) Elements are created and destroyed as they move through the Earth system.
(C) The total amount of an element on Earth is fixed, but it moves between different reservoirs.
(D) Geochemical cycles only apply to radioactive elements.

197. Which pair of radioactive decay schemes is most suitable for dating very ancient rocks (billions of years old)?
(A) Carbon-14 and K-Ar
(B) U-Pb and Rb-Sr
(C) K-Ar and Tritium
(D) Sm-Nd and Carbon-14

198. An element that has a strong affinity for oxygen and is concentrated in the Earth's silicate crust and mantle is classified as:
(A) Chalcophile.
(B) Siderophile.
(C) Atmophile.
(D) Lithophile.

199. What is the daughter product of the beta decay of Rubidium-87 (^{87}Rb)?
(A) Strontium-87 (^{87}Sr)
(B) Strontium-86 (^{86}Sr)
(C) Yttrium-87 (^{87}Y)
(D) Rubidium-86 (^{86}Rb)

200. The composition of the Earth's core is inferred to be primarily an iron-nickel alloy. This is consistent with the concentration of which type of elements?
(A) Lithophile
(B) Atmophile
(C) Siderophile
(D) Chalcophile

201. The decay of Potassium-40 (^{40}K) is unique among common geochronometers because it has a branched decay to:
(A) ^{40}Ar and ^{40}Ca.
(B) ^{40}Sr and ^{40}Ar.
(C) ^{40}Ca and ^{39}Ar.
(D) ^{39}K and ^{40}Ar.

202. Which of the following is an example of a sulfide mineral with an AX_2 structure?
(A) Galena (PbS)
(B) Sphalerite (ZnS)
(C) Argentite (Ag_2S)
(D) Pyrite (FeS_2)

203. The relationship between diamond and graphite, both pure carbon, is an example of:
(A) Isomorphism.
(B) Polymorphism.
(C) Exsolution.
(D) Solid solution.

204. Gypsum ($CaSO_4 \cdot 2H_2O$) is classified as a:
(A) anhydrous sulfate.
(B) carbonate.
(C) hydrous sulfate.
(D) oxide.

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205. In the classification of silicates, which structural type is represented by the amphibole group?
(A) Nesosilicate
(B) Tectosilicate
(C) Phyllosilicate
(D) Inosilicate (double chain)

206. Which of the following statements about the aragonite group of carbonates is incorrect?
(A) They are isostructural with calcite.
(B) They have the general formula RCO_3.
(C) They crystallize in the orthorhombic system.
(D) Aragonite ($CaCO_3$) is a key member.

207. The solid solution between two or more minerals with the same structure but different chemistry is known as:
(A) a polymorphic series.
(B) an isomorphous series.
(C) an exsolution series.
(D) a reaction series.

208. To which mineral group does hematite (Fe_2O_3) belong?
(A) XO type oxides
(B) X_2O_3 type oxides

a cooling mafic magma, according to Bowen's Reaction Series:
1. Quartz
2. Amphibole (Hornblende)
3. Pyroxene (Augite)
4. Olivine

Select the correct answer using the code given below:
(A) 1, 2, 3, 4
(B) 4, 3, 2, 1
(C) 4, 2, 3, 1
(D) 2, 4, 1, 3

252. Which of the aluminosilicate polymorphs is characteristic of contact metamorphism, where temperatures are high but pressures are low?
(A) Kyanite
(B) Sillimanite
(C) Andalusite
(D) Staurolite

253. The iron-rich end member of the olivine solid solution series is named:
(A) Forsterite.
(B) Ferrosilite.
(C) Hedenbergite.
(D) Fayalite.

254. What is the fundamental reason for the lack of cleavage in quartz?
(A) The Si-O bonds are equally strong in all directions within its framework structure.
(B) It is amorphous.
(C) It has a very low hardness.
(D) It belongs to the hexagonal crystal system.

255. Pistachio green color is highly characteristic of which mineral?
(A) Olivine
(B) Epidote
(C) Chlorite
(D) Diopside

256. Which of the following is a key characteristic of the garnet group minerals?
(A) They are sheet silicates with perfect cleavage.
(B) They are nesosilicates, often forming equant (dodecahedral or trapezohedral) crystals.
(C) They are typically found in low-grade sedimentary rocks.
(D) They are very soft and easily weathered.

257. Ruby and sapphire are precious gem varieties of the mineral:
(A) Corundum (Al_2O_3)
(B) Beryl ($Al_2Be_3Si_6O_{18}$)
(C) Quartz (SiO_2)
(D) Topaz ($Al_2SiO_4(F,OH)_2$)

258. The 'play-of-color' in precious opal is a physical phenomenon caused by:
(A) chemical impurities.
(B) radioactive decay.
(C) diffraction of light from a regular packing of microscopic silica spheres.
(D) double refraction.

259. Which of these minerals is classified as a phyllosilicate and is a common indicator of low-grade metamorphism?
(A) Sillimanite
(B) Garnet
(C) Staurolite
(D) Chlorite

260. Anisotropic minerals are optically distinguished from isotropic minerals because they:
(A) are always colored.
(B) have a single refractive index.
(C) show double refraction.
(D) are opaque to transmitted light.

261. When using the immersion method, if the Becke line moves out of the grain into the surrounding oil when the stage is lowered, it means:
(A) n(mineral) > n(oil).
(B) n(mineral) < n(oil).
(C) n(mineral) = n(oil).
(D) the mineral is isotropic.

262. The maximum interference color observed for an anisotropic mineral in thin section depends on the mineral's orientation, thickness, and:
(A) relief.
(B) density.
(C) pleochroism.
(D) birefringence.

263. Minerals of the orthorhombic, monoclinic, and triclinic systems are optically:
(A) biaxial.

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3. Olivine Group
4. Epidote Group

Codes:
(A) P-1, Q-3, R-2, S-4
(B) P-3, Q-1, R-4, S-2
(C) P-4, Q-2, R-1, S-3
(D) P-3, Q-4, R-2, S-1

219. The defining characteristic of the olivine group is its structure of:
(A) sheets of silica tetrahedra.
(B) isolated silica tetrahedra linked by cations.
(C) a framework of silica tetrahedra.
(D) double chains of silica tetrahedra.

220. Which statement regarding the properties of quartz is incorrect?
(A) It has a hardness of 7 on the Mohs scale.
(B) It is chemically stable and resistant to weathering.
(C) It commonly exhibits perfect rhombohedral cleavage.
(D) It is a major component of granite and sandstone.

221. The characteristic pistachio-green color is a diagnostic property of which common metamorphic mineral?
(A) Chlorite
(B) Serpentine
(C) Glaucophane
(D) Epidote

222. What is the structural classification of chlorite group minerals?
(A) Phyllosilicate
(B) Nesosilicate
(C) Inosilicate
(D) Tectosilicate

223. Which of the following is a semi-precious gem variety of corundum?
(A) Ruby is categorized as a semi-precious gem variety of corundum.
(B) All varieties of corundum are considered precious stones.
(C) Sapphire is categorized as a semi-precious gem variety of corundum.
(D) Emerald is categorized as a semi-precious gem variety of corundum.

NODIA

224. A student observes a mineral under the microscope that is isotropic. Which of the following could it be?
(A) Quartz
(B) Garnet
(C) Calcite
(D) Hornblende

225. Consider the following statements regarding optical properties of minerals:
Statement I : The phenomenon of double refraction occurs because the velocity of light varies with direction in an anisotropic mineral.
Statement II : Birefringence is the quantitative measure of the total double refraction of a mineral.
Which of the above statement(s) is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

226. A mineral grain is immersed in an oil with a refractive index of 1.54. When the microscope stage is lowered, the Becke line moves into the mineral grain. This indicates that the refractive index of the mineral is:
(A) less than 1.54.
(B) equal to 1.54.
(C) greater than 1.54.
(D) cannot be determined from this information.

227. The splitting of an incident light ray into an ordinary ray (O-ray) and an extraordinary ray (E-ray) is a defining characteristic of:
(A) isotropic minerals.
(B) opaque minerals.
(C) amorphous materials.
(D) uniaxial minerals.

228. What is the main principle behind the optical classification of minerals?
(A) Their chemical composition, specifically the presence of iron.
(B) Their hardness and specific gravity.
(C) Their behavior in response to passing light, which is determined by their internal crystal structure.
(D) Their mode of geological occurrence.

certain ions while allowing others to pass, and can host and release water and other molecules. Which of the following is correct?
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

276. Which of the following is a double-chain silicate?
(A) Diopside
(B) Olivine
(C) Hornblende
(D) Muscovite

277. The chemical formula for quartz is:
(A) Al_2SiO_5
(B) SiO_2
(C) $CaCO_3$
(D) $KAlSi_3O_8$

278. Match List I with List II and select the correct answer using the codes given below:
List I: (Mineral)
P. Calcite
Q. Gypsum
R. Pyrite
S. Magnetite
List II: (Defining Property or Classification)
1. Hydrous sulfate
2. XY_2O_4 type oxide
3. AX_2 type sulfide
4. Rhombohedral carbonate
Codes:
(A) P-1, Q-3, R-2, S-4
(B) P-4, Q-1, R-3, S-2
(C) P-4, Q-2, R-1, S-3
(D) P-3, Q-4, R-2, S-1

279. The stability fields of kyanite, andalusite, and sillimanite are a function of:
(A) Pressure and Temperature.
(B) Silica activity and Temperature.
(C) Oxygen fugacity and Pressure.
(D) Water content and pH.

280. In optical mineralogy, what does the term 'relief' describe?
(A) The range of interference colors a mineral displays.
(B) The variation of color with orientation (pleochroism).
(C) The contrast in refractive index between a mineral and its mounting medium.
(D) The angle at which a mineral goes extinct under crossed polars.

281. The geochemical composition of the Earth as a whole is thought to be best represented by the composition of:
(A) Chondritic meteorites.
(B) Granites.
(C) Basalts.
(D) The atmosphere.

282. The decay of ^{235}U to ^{207}Pb is an example of a:
(A) single-step beta decay.
(B) branched decay to two different elements.
(C) stable isotope transformation.
(D) radioactive decay series.

283. Which mineral group is defined by a structure of isolated (SiO_4) tetrahedra?
(A) Pyroxene
(B) Olivine
(C) Mica
(D) Feldspar

284. A mineral shows perfect cleavage in one direction, producing thin, elastic sheets. Which mineral could it be?
(A) Quartz
(B) Calcite
(C) Muscovite
(D) Feldspar

285. What is the fundamental building block of all silicate minerals?
(A) The $(CO_3)^{2-}$ triangle
(B) The $(SO_4)^{2-}$ tetrahedron
(C) The (AlO_6) octahedron
(D) The $(SiO_4)^{4-}$ tetrahedron

286. Which of the following is NOT a polymorph of Al_2SiO_5?
(A) Staurolite
(B) Kyanite
(C) Andalusite
(D) Sillimanite

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287. The most abundant mineral group in the Earth's crust is the:
(A) Carbonate group.
(B) Feldspar group.
(C) Pyroxene group.
(D) Oxide group.

288. In the K-Ar dating method, which isotope is the parent and which is the daughter?
(A) Parent: ^{40}K, Daughter: ^{40}Ar
(B) Parent: ^{40}K, Daughter: ^{40}Ca
(C) Parent: ^{39}Ar, Daughter: ^{39}K
(D) Parent: ^{40}Ar, Daughter: ^{40}K

289. The term 'chalcophile' in geochemistry refers to elements that have a strong affinity for:
(A) Sulfur.
(B) Oxygen.
(C) Iron.
(D) Water.

290. Which of the following optical phenomena is only possible in anisotropic minerals?
(A) Refraction
(B) Reflection
(C) Birefringence
(D) Absorption

291. The solid solution series between Albite ($NaAlSi_3O_8$) and Anorthite ($CaAl_2Si_2O_8$) defines the:
(A) Alkali feldspars.
(B) Pyroxenes.
(C) Feldspathoids.
(D) Plagioclase feldspars.

292. The law of thermodynamics that relates heat, work, and internal energy is the:
(A) Zeroth Law.
(B) Second Law.
(C) First Law.
(D) Third Law.

293. What is the silicate structure of the mineral quartz?
(A) Nesosilicate
(B) Tectosilicate
(C) Phyllosilicate
(D) Inosilicate

294. Which of the following is a precious stone?
(A) Agate
(B) Turquoise
(C) Lapis Lazuli
(D) Diamond

295. The green color of chlorite is due to the presence of:
(A) Iron and Magnesium.
(B) Potassium and Aluminum.
(C) Sodium and Calcium.
(D) Silicon and Oxygen.

296. A mineral that has a single optic axis is defined as:
(A) Isotropic.
(B) Biaxial.
(C) Uniaxial.
(D) Pleochroic.

297. The radioactive decay of an element is a process that occurs at a rate that is:
(A) constant and not affected by physical or chemical conditions.
(B) dependent on temperature and pressure.
(C) faster in the past than it is today.
(D) dependent on the host mineral's crystal structure.

298. In the context of a geochemical cycle, a 'reservoir' is:
(A) a man-made lake.
(B) the process by which an element moves.
(C) a mineral that contains the element in high concentration.
(D) a specific component of the Earth system where an element resides.

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299. The chemical composition of the Earth's mantle is best described as:
(A) Felsic.
(B) Ultramafic.
(C) Granitic.
(D) Carbonaceous.

300. Which of the following minerals is commonly used in U–Pb radiometric dating because it incorporates uranium but excludes lead during crystallization?
(A) Quartz
(B) Zircon
(C) Feldspar

(D) Calcite

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by hydroxyl ions, fluorine, or chlorine. This hydrous nature reflects the environment of their formation, usually involving water-rich conditions.

36. (A) Both A and R are true and R is the correct explanation of A.
Feldspathoids are silica-undersaturated minerals that only form when there is insufficient silica to produce feldspars. If free silica, such as quartz, were present in the magma, it would react with the feldspathoids to form the corresponding feldspar minerals. Therefore, quartz and feldspathoids are chemically incompatible and do not occur together in equilibrium within the same igneous rock during the crystallization process.

37. (C) Hornblende
Hornblende is a common rock-forming mineral that belongs to the amphibole group, not the pyroxene group. It is characterized by its double-chain silicate structure and the presence of hydroxyl groups. In contrast, augite, diopside, and enstatite are all members of the pyroxene group, which are defined by their single-chain silicate structure and their characteristic cleavage angles that intersect at nearly 90 degrees.

38. (A) Both Statement I and Statement II are true.
Pyroxenes are structurally defined as single-chain inosilicates, where silica tetrahedra share two corners to form continuous strings. Amphiboles are structurally more complex, consisting of double chains. A key chemical requirement for the amphibole structure is the inclusion of hydroxyl (OH) ions, which fill a specific site within the lattice. Both statements accurately reflect the fundamental structural and chemical definitions of these important mineral groups.

39. (B) P-3, Q-1, R-4, S-2
Feldspars are framework silicates with a shared oxygen framework. Pyroxenes are single-chain silicates with a specific one-to-three silicon-oxygen ratio. Micas are sheet silicates famous for their perfect basal cleavage. Zeolites are framework silicates distinguished by their open channels containing water molecules. This matching accurately links each mineral group to its most defining structural or chemical characteristic as recognized in the standard geological classification.

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40. (A) Perfect basal cleavage
The mica group minerals are sheet silicates where atoms are strongly bonded within two-dimensional layers. The forces holding these layers together are relatively weak, allowing the mineral to split easily into very thin, flexible sheets. This property, known as perfect basal cleavage, is the most distinctive physical characteristic of minerals like muscovite and biotite and is a direct consequence of their layered atomic structure.

41. (C) Feldspathoids are deficient in silica.
The primary chemical difference between feldspars and feldspathoids is the amount of silica relative to the alkali metals and aluminum. Feldspathoids have significantly less silica in their formulas, which is why they only crystallize from magmas that are silica-undersaturated. If more silica were available, these minerals would react to form feldspars instead. This deficiency defines their occurrence and distinguishes them from the more common feldspar group.

42. (A) plagioclase feldspars.
The plagioclase series is a continuous solid solution between the sodium end-member, albite, and the calcium end-member, anorthite. Because sodium is monovalent and calcium is divalent, a coupled substitution is required to maintain electrical neutrality in the crystal lattice. This involves replacing a silicon atom with an aluminum atom, resulting in the characteristic exchange of $Na+Si4+$ for $Ca2+Al3+$ within the framework structure.

43. (D) They are anhydrous silicates.
Zeolites are actually hydrous aluminosilicates. Their open framework structure contains large cavities and channels that host water molecules and exchangeable cations. This water is loosely held and can be removed or replaced by heating without destroying the mineral's crystal structure. Therefore, the statement that they are anhydrous is incorrect, as the presence of structural water is a fundamental and defining characteristic of the zeolite group.

44. (B) Pyroxene
Augite is the most common member of the pyroxene group and is a primary constituent of mafic and ultramafic igneous rocks like basalt and gabbro. It is a single-chain inosilicate that

9. (A) P-3, Q-4, R-1, S-2
Periclase represents the simple XO type oxide with a cubic structure. Rutile is a classic XO_2 oxide found in various geological settings. Corundum follows the X_2O_3 formula, consisting of aluminum and oxygen. Spinel group minerals follow the XY_2O_4 structure, involving both divalent and trivalent cations. Together, these examples illustrate the diverse structural classifications used for oxide minerals in mineralogy.

10. (A) Gypsum
Gypsum is a hydrous sulfate mineral because its crystal structure contains molecular water, represented by the formula $CaSO_4 \cdot 2H_2O$. In contrast, barite, anhydrite, and celestite are anhydrous sulfates, meaning they do not contain water in their chemical formulas. Anhydrite is essentially the water-free equivalent of gypsum and can be transformed into gypsum through the process of hydration in nature.

11. (D) The lattice dimensions change slightly, though the overall structure remains.
When ions substitute for each other in an isomorphous series, the fundamental crystal structure remains unchanged. However, because substituting ions usually have slightly different radii, the dimensions of the unit cell and the entire crystal lattice will expand or contract accordingly. This subtle change in geometry maintains the overall symmetry while allowing for a continuous variation in the mineral's chemical composition.

12. (A) 4, 2, 1, 3
Silicate complexity increases based on the number of shared oxygen atoms between silica tetrahedra. Isolated tetrahedra share no oxygens. Single chains share two oxygens, forming long strings. Sheet silicates share three oxygens to form planar layers. Finally, framework silicates share all four oxygen atoms, creating a rigid three-dimensional structure. This progression represents the fundamental basis for the structural classification of silicates.

13. (C) A2X
Chalcocite is a copper sulfide mineral with the chemical formula Cu_2S. In the classification of sulfide structures, this corresponds to the A_2X type, where there are two metal cations for every sulfur anion. This specific ratio results in a unique atomic packing compared to the more common AX type sulfides, affecting its physical properties such as density and crystal habit.

14. (D) They are anhydrous RCO_3 carbonates that belong to the orthorhombic system.
The aragonite group includes anhydrous carbonate minerals that follow the general chemical formula RCO_3 but crystallize in the orthorhombic system. This distinguishes them from the calcite group, which is trigonal. Members of this group, such as aragonite, strontianite, and witherite, typically involve larger divalent cations that do not fit into the tighter trigonal lattice arrangement seen in calcite.

15. (A) A silicon atom bonded to four oxygen atoms (SiO_4)
The silica tetrahedron, consisting of a central silicon cation surrounded by four oxygen anions, is the fundamental building block of all silicate minerals. These tetrahedra can exist independently or link together by sharing oxygen atoms at their corners. The various ways these units are connected determine the structure, properties, and classification of the vast majority of rock-forming minerals found.

NODIA

16. (B) All minerals in this group are silicates.
The spinel group consists of oxide minerals, not silicates. These minerals share a general chemical formula of XY_2O_4, where X and Y are divalent and trivalent metallic cations. Important members like magnetite and chromite are oxides that crystallize in the isometric system. While they are often found in silicate rocks, their chemical structure is fundamentally based on oxygen-cation bonding.

17. (B) Polymorphism
Calcite and aragonite both have the chemical formula $CaCO_3$, making them polymorphs of calcium carbonate. Calcite is the stable form at surface conditions, while aragonite forms under high-pressure environments or through biological processes. Because they have the same chemistry but different crystal structures, they exhibit different physical properties such as hardness, density, and cleavage, which is characteristic of polymorphic substances.

ANSWERS

1. (B) Galena
Galena, composed of lead sulfide, crystallizes in the isometric system and follows the AX structural arrangement. In this configuration, the ratio of metal cations to sulfur anions is exactly one to one. It shares a similar atomic packing to halite, where each lead atom is surrounded by six sulfur atoms in a specific octahedral coordination pattern.

2. (A) Both Statement I and Statement II are true.
Polymorphism refers to the ability of a single chemical compound to exist in more than one crystal structure depending on environmental conditions like pressure and temperature. Since these polymorphs originate from the same chemical formula, they are chemically identical despite having different physical arrangements of atoms. Common examples include diamond and graphite, or the calcite and aragonite mineral pair.

3. (D) 1, 2 and 3
Oxide minerals are classified based on the ratio of cations to oxygen. The XO type, like periclase, has a one-to-one ratio. The XO_2 type, including rutile, contains two oxygen atoms for every cation. The complex XY_2O_4 structure defines the spinel group, where X and Y represent divalent and trivalent cations respectively, filling specific sites in the lattice.

4. (D) AX2 type
Pyrite, commonly known as fool's gold, has the chemical formula FeS_2, which fits the AX2 structural classification. In this arrangement, iron serves as the cation while sulfur forms disulfide pairs. Although it resembles the isometric galena structure, the orientation of these sulfur pairs reduces the overall symmetry compared to simpler AX type sulfide minerals found in nature.

5. (C) Minerals with the same crystal structure but different chemical compositions.
Isomorphism describes a phenomenon where different chemical substances possess nearly identical crystal structures and can form solid solutions. This occurs when ions of similar size and charge substitute for one another within the same lattice framework. Consequently, the resulting minerals share similar physical properties and symmetry despite having distinct chemical formulas, such as in the plagioclase feldspar series.

6. (A) Both A and R are true and R is the correct explanation of A.
Calcite and aragonite are classic examples of polymorphs because they share the identical chemical formula of calcium carbonate. Their differences arise from the different pressure and temperature conditions during formation, leading to distinct crystal systems and physical properties. This structural variation is exactly what defines polymorphism in mineralogy, where the internal atomic arrangement differs despite having the same chemistry.

7. (D) They have a general formula of RCO_3 and belong to the trigonal crystal system.
The calcite group consists of anhydrous carbonates with the general formula RCO_3 , where R represents divalent cations like calcium, magnesium, or iron. These minerals crystallize in the trigonal system, specifically within the hexagonal scalenohedral class. They are characterized by a strong rhombohedral cleavage, which is a direct consequence of their internal atomic arrangement and the symmetry of their crystals.

8. (A) the breakdown of a solid solution that is stable only at high temperatures.
Exsolution is the process where a single solid solution phase separates into two or more distinct mineral phases during cooling. This occurs because the initial homogeneous mixture becomes unstable at lower temperatures, forcing the different ions to organize into separate crystal lattices. A common example is the formation of perthitic textures in alkali feldspars, where sodium and potassium separate.

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27. (D) Mica group
The mica group consists of phyllosilicates characterized by continuous sheets of silica tetrahedra. In these minerals, each tetrahedron shares three oxygen atoms with its neighbors, resulting in a structural sheet with the general composition of (Al,Si)4O10. These sheets are separated by layers of cations, allowing the minerals to split easily into thin, flexible plates along their perfect basal cleavage planes during identification.

28. (B) open framework structure featuring large channels and cavities.
Zeolites are tectosilicates with an exceptionally open three-dimensional framework. This structure contains large, interconnected channels and cavities that can accommodate water molecules and various cations. Because the bonds in the silicate framework are very strong, the water can be removed or replaced without collapsing the crystal lattice. This unique property enables zeolites to function effectively as molecular sieves and ion exchangers.

29. (C) Pyroxenes are single-chain silicates, while amphiboles are double-chain silicates.
Pyroxenes are categorized as single-chain inosilicates because their silica tetrahedra share two corners to form a simple line. Amphiboles are double-chain inosilicates because two of these single chains are linked together, with some tetrahedra sharing three oxygen atoms. This structural distinction is the primary basis for classifying these two major groups of ferromagnesian minerals and explains their differing physical and chemical properties.

30. (D) Nepheline
Nepheline is a common feldspathoid mineral that typically occurs in alkaline, silica-undersaturated igneous rocks. Unlike orthoclase, albite, and anorthite, which are all types of feldspars, nepheline has a lower silica content. Its presence in a rock indicates that the parent magma was deficient in silica, preventing the formation of more common framework silicates like albite or the stable presence of quartz.

31. (A) double-chain silicate structure.
The characteristic cleavage of amphiboles is a direct result of their double-chain silicate structure. The weak bonds between these complex chains are oriented in such a way that the mineral breaks along planes intersecting at 56° and 124°. This diagnostic property allows geologists to distinguish amphiboles from pyroxenes, which have single-chain structures and cleavage angles much closer to 90 degrees in specimen.

32. (B) strong bonds within silicate sheets and weak forces between them.
Micas have a sheet silicate structure where silica tetrahedra are strongly bonded together in two-dimensional layers. These layers are held together by relatively weak ionic bonds through interlayer cations like potassium. Because the bonds within the sheets are much stronger than the bonds between them, the mineral easily splits along these planar boundaries, producing the characteristic perfect basal cleavage seen in muscovite.

33. (D) 1, 2 and 3
Feldspars are the most abundant mineral group in the Earth's crust, forming a major component of most igneous, metamorphic, and sedimentary rocks. They are framework silicates where every oxygen atom is shared between tetrahedra. The group is primarily classified into alkali feldspars, containing potassium and sodium, and plagioclase feldspars, which represent a solid solution series between sodium and calcium end-members.

34. (A) Leucite
Leucite is a potassium-rich feldspathoid mineral that typically forms in silica-undersaturated volcanic rocks. It often crystallizes as equant, trapezohedral crystals that appear glassy and light-colored. Since it is a feldspathoid, it indicates a deficiency of silica in the magma. Unlike quartz, which would never coexist with it, leucite has a distinct crystal habit and lacks the cleavage seen in most other silicate minerals.

35. (C) Amphibole
The amphibole group of minerals is chemically distinguished from the pyroxene group by the essential presence of the hydroxyl (OH) radical in their crystal structure. While both are inosilicates, the double-chain structure of amphiboles creates a large site in the lattice that must be occupied

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18. (A) Olivine - Isolated tetrahedra silicates
Olivine is a classic example of a nesosilicate, where individual silica tetrahedra are isolated from one another and linked only by metallic cations. In contrast, pyroxenes are single-chain silicates, amphiboles are double-chain silicates, and micas are sheet silicates. These classifications are based on how the silica tetrahedra share oxygen atoms, which fundamentally dictates the mineral group's cleavage and crystal habit.

19. (C) $CaMg(CO_3)_2$
Dolomite is a double carbonate mineral characterized by an ordered arrangement of calcium and magnesium ions in its crystal structure. Its chemical formula is $CaMg(CO_3)_2$, reflecting the equal proportion of these two cations. This specific ordering results in a lower symmetry compared to the calcite group minerals, placing dolomite in its own distinct structural group within the trigonal crystal system.

20. (D) High pressure and relatively low temperature
Aragonite is the high-pressure polymorph of calcium carbonate. In the $CaCO_3$ phase diagram, aragonite becomes the stable form as pressure increases, whereas calcite is the stable form at lower pressures. Therefore, geological environments characterized by high pressure and relatively low temperatures favor the crystallization of aragonite. This is why aragonite is often found in blueschist facies metamorphic rocks and shells.

21. (C) 1:3
Single chain silicates, known as inosilicates, are formed by silica tetrahedra linked together in a continuous string. Each tetrahedron shares two of its oxygen atoms with adjacent units. This sharing arrangement results in a silicon to oxygen ratio of 1:3, typically expressed in formulas as SiO_3. This structural pattern is the defining characteristic of the pyroxene mineral group and related minerals.

22. (B) Anhydrous sulfate
Barite, with the chemical formula $BaSO_4$, consists of barium cations and sulfate anions without any molecular water in its structure. Consequently, it is classified as an anhydrous sulfate. This group of minerals is distinct from hydrous sulfates, like gypsum, which contain water molecules. Barite is known for its high specific gravity and is a common mineral in hydrothermal vein deposits.

23. (D) Color
Hardness, cleavage, and crystal form are all intrinsic physical properties determined by the internal arrangement of atoms and the strength of their chemical bonds. In contrast, color in minerals is often caused by trace element impurities, defects in the crystal lattice, or the presence of specific transition metals. Therefore, color is generally considered an extrinsic property and is not solely dependent on structure.

24. (A) silicate structure, with pyroxenes being single chains and amphiboles double.
The fundamental difference between these two groups is the linkage of their silica tetrahedra. Pyroxenes consist of single chains where tetrahedra share two oxygens, while amphiboles consist of double chains where some tetrahedra share two and others share three oxygens. This structural difference directly influences their chemical formulas, particularly the inclusion of hydroxyl groups in amphiboles, and their characteristic cleavage angles.

25. (C) poorer in silica compared to feldspars.
Feldspathoids are aluminosilicate minerals that form from magmas that do not contain enough silica to produce feldspars. Chemically, they are similar to feldspars but contain a lower proportion of silicon relative to aluminum and alkali metals. Because they are silica-undersaturated, they never occur naturally in equilibrium with quartz, as they would react with any available free silica to form feldspar.

26. (A) They are single-chain silicates with a characteristic cleavage angle of near 90°.
The pyroxene group is defined by a single-chain inosilicate structure where silica tetrahedra are linked in a continuous line. This internal arrangement produces two directions of prismatic cleavage that intersect at approximately 87° and 93°, which is typically simplified to 90°. Unlike amphiboles, pyroxenes are generally anhydrous and lack the hydroxyl groups that are essential to the double-chain silicate mineral structure.

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typically contains calcium, magnesium, and iron. Augite is recognized in hand specimens by its dark green to black color and its characteristic two directions of cleavage that intersect at approximately 90 degrees.

45. (C) the hydroxyl (OH) radical.
The complex structure of amphiboles, consisting of double chains of silica tetrahedra, results in a lattice that includes a large A" site and a specific site for hydroxyl (OH) ions. The presence of these hydroxyl groups is a fundamental chemical requirement for all amphiboles, making them hydrous minerals. This distinguishes them from the structurally similar but typically anhydrous pyroxenes, which lack these essential hydroxyl components.

46. (D) Albite and Anorthite
Albite and anorthite are the two end-members of the plagioclase feldspar group. They form a complete solid solution series, where sodium and calcium, along with silicon and aluminum, substitute for each other while maintaining the same framework crystal structure. This is a classic example of isomorphism, where the minerals share a common structure but vary continuously in their chemical composition between the two end-members.

47. (A) silica-undersaturated.
Nepheline, leucite, and sodalite are all members of the feldspathoid group. These minerals are chemically deficient in silica compared to feldspars and only crystallize from magmas that lack enough silica to form quartz. Therefore, the presence of these minerals in a rock is a definitive indicator that the parent magma was silica-undersaturated, meaning it did not have enough silica to saturate all available cations.

48. (B) Two directions at ~90 degrees
The single-chain silicate structure of pyroxenes consists of tetrahedra linked together in rows. In the crystal lattice, these chains are arranged such that the zones of weakest bonding occur along planes that intersect at nearly right angles. This results in the characteristic two directions of prismatic cleavage, with angles of approximately 87° and 93°, which are commonly observed and used for identification in hand specimens.

49. (B) Orthoclase
Orthoclase is a common member of the alkali feldspar group with the chemical formula KAlSi3O8. It is rich in potassium and is a major constituent of felsic igneous rocks like granite. While albite is the sodium end-member, and anorthite and labradorite are members of the plagioclase series, orthoclase represents one of the primary minerals where potassium is the dominant alkali metal in the structure.

50. (A) Tectosilicates
Zeolites are classified as tectosilicates, or framework silicates, because their atomic structure consists of a three-dimensional network of silica and alumina tetrahedra. In this arrangement, every oxygen atom is shared between two tetrahedra. This creates a very rigid but open framework with large internal cavities, which is the defining structural feature of zeolites and allows for their unique ion-exchange and dehydration properties.

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51. (C) Iron and Magnesium
Both muscovite and biotite are sheet silicates in the mica group, but they differ significantly in their chemical composition. Muscovite is a light-colored mica rich in aluminum and potassium. Biotite, known as dark mica, contains substantial amounts of iron and magnesium in its octahedral sites. This higher concentration of ferromagnesian elements gives biotite its characteristic dark brown to black color and its different optical properties.

52. (D) 4:11
In the double-chain structure of amphiboles, some silica tetrahedra share two oxygen atoms while others share three. This specific arrangement leads to a repeating structural unit with the formula Si4O11. Consequently, the fundamental silicon to oxygen ratio in the amphibole framework is 4:11. This ratio is intermediate between the 1:3 ratio of single-chain pyroxenes and the 2:5 ratio of sheet silicates like micas.

53. (C) Cleavage angle
While pyroxenes and amphiboles share similar colors and lusters, they can be reliably distinguished in hand specimens by their cleavage. Pyroxenes have two directions of

cleavage that intersect at nearly 90 degrees. Amphiboles, due to their double-chain structure, exhibit two directions of cleavage that intersect at approximately 56° and 124°. Observing these angles is the most standard method for differentiating these two important mineral groups.

54. (B) Feldspar
The feldspar group consists of framework silicates where the structure is built from a three-dimensional network of (Al, Si)O_2 tetrahedra. Because they can incorporate a variety of cations like potassium, sodium, and calcium, they are incredibly versatile and form the most abundant mineral group in the Earth's crust. Feldspars make up approximately 60% of the total volume of the crust, occurring in nearly all rock types.

55. (D) Alkali feldspars
Perthite is a texture characterized by parallel lamellae of sodium-rich feldspar (albite) within a host of potassium-rich feldspar (orthoclase or microcline). This occurs in alkali feldspars that were initially a homogeneous solid solution at high temperatures but underwent exsolution as they cooled. Because the sodium and potassium ions have different sizes, they become incompatible at lower temperatures and separate into these distinct, visible intergrowths.

56. (A) They crystallize from silica-deficient magmas.
Feldspathoids are aluminosilicate minerals that are chemically undersaturated with respect to silica. They only form when the parent magma lacks sufficient silicon to produce common feldspar minerals. As a result, they never occur in rocks that contain primary quartz. This characteristic environmental requirement is true for all members of the feldspathoid group, including minerals like nepheline, leucite, and sodalite, regardless of their specific crystal system.

57. (C) sheets of silica tetrahedra bonded by layers of cations.
The structure of micas consists of continuous two-dimensional sheets where each silica tetrahedron shares three of its oxygen atoms with neighboring units. These anionic sheets are held together by layers of cations like potassium, sodium, or calcium. This arrangement creates a very strong bond within the sheets but a relatively weak bond between them, which explains the characteristic perfect basal cleavage that allows micas to split into thin layers.

58. (A) Albite
Albite is the sodium-rich end-member of both the alkali feldspar and the plagioclase feldspar series, with the chemical formula NaAlSi3O8. In the plagioclase series, it represents the 0-10% calcium range. As the calcium content increases, the mineral progresses through other members like oligoclase and labradorite until it reaches the pure calcium end-member, anorthite. Albite is a common mineral in many igneous and metamorphic rocks.

59. (D) Biaxial
All minerals in the feldspar group crystallize in either the monoclinic or triclinic crystal systems. According to the principles of optical mineralogy, minerals belonging to these lower-symmetry systems are always biaxial. This means they possess two optic axes and three principal refractive indices. This optical property is consistent across all varieties of feldspar, including orthoclase, microcline, and the entire plagioclase series, regardless of their specific chemical composition.

60. (B) Natrolite
Natrolite is a common member of the zeolite group, often found filling cavities in volcanic rocks like basalt. Like all zeolites, it is a hydrous framework silicate characterized by an open structure that allows for ion exchange. Augite is a pyroxene, hornblende is an amphibole, and sodalite is a feldspathoid. Natrolite specifically forms slender, needle-like crystals and is a classic example of this chemically and structurally unique mineral group.

61. (C) X = divalent cations, Y = trivalent cations
In the general formula for garnets, $X_3Y_2(SiO_4)_3$, the X site is a large dodecahedral site occupied by divalent cations such as calcium, magnesium, iron, or manganese. The Y site is a smaller octahedral site occupied by trivalent cations like aluminum, iron, or chromium. This diverse range of possible cation substitutions leads to the many different varieties within the garnet group, while

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the isolated silicate tetrahedra remain a constant feature.

62. (D) temperature and pressure.
Kyanite, sillimanite, and andalusite are all polymorphs of Al_2SiO_5, meaning they have the same chemical composition but different crystal structures. Each mineral is stable only within a specific range of temperature and pressure. Therefore, their presence in a metamorphic rock serves as a sensitive geothermobarometer, allowing geologists to determine the specific physical conditions that existed during the metamorphism of the host rock in the Earth's crust.

63. (D) 1, 2 and 3
Quartz is a ubiquitous mineral composed of SiO_2 in a three-dimensional framework. Because the Si-O bonds are equally strong in all directions, it lacks cleavage and instead breaks with a characteristic conchoidal fracture. Pure quartz is colorless, but trace amounts of impurities can produce vibrant varieties like purple amethyst or yellow citrine. These features make quartz one of the most recognizable and important minerals in geological studies.

64. (B) Olivine
Olivine is a completely separate group of silicate minerals and is not a variety of quartz. Quartz varieties, like amethyst, citrine, and rose quartz, are distinguished by their colors which result from trace impurities or structural defects within the SiO_2 framework. Olivine, however, is a nesosilicate with a different chemical formula and structure. It is typically green and occurs in mafic and ultramafic rocks where quartz is usually absent.

65. (B) Fayalite and Forsterite
The olivine group forms a complete solid solution series between two end-members: forsterite, which is the magnesium-rich member (Mg_2SiO_4), and fayalite, which is the iron-rich member (Fe_2SiO_4). In nature, most olivine crystals contain a mixture of both magnesium and iron. The relative proportion of these two elements depends on the composition of the magma from which the mineral crystallized, with magnesium-rich varieties being more common in the mantle.

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66. (A) Both A and R are true and R is the correct explanation of A.
Garnets are essential index minerals because their appearance and specific chemical composition change predictably with the temperature and pressure of metamorphism. As the metamorphic grade increases, the garnet's chemistry shifts to incorporate different divalent and trivalent cations. This allows petrologists to use the presence and composition of garnets to map out zones of metamorphic intensity, providing a reliable record of the geological history of a region.

67. (C) Forsterite
Forsterite is the pure magnesium end-member of the olivine group, with the chemical formula Mg_2SiO_4. It is a common mineral in ultramafic rocks and is often found in the Earth's upper mantle. While zircon, epidote, and staurolite are all silicate minerals, they belong to different structural groups. Forsterite exhibits the characteristic isolated tetrahedra structure of nesosilicates and the typical light green color associated with many olivine varieties.

68. (D) micas.
Chlorite minerals are sheet silicates that share a similar layered structure with micas. Structurally, they consist of mica-like layers alternating with brucite-like layers of magnesium and iron hydroxide. This arrangement results in a platy habit and perfect basal cleavage, much like muscovite or biotite. Because of these structural and chemical similarities, chlorites are often classified together with micas in the broader phyllosilicate group of rock-forming minerals.

69. (B) P-3, Q-2, R-1, S-4
Kyanite is the high-pressure polymorph, stable in deep crustal environments. Andalusite is stable at low pressures and moderate temperatures, often found in contact metamorphic aureoles. Sillimanite is the high-temperature polymorph, appearing in high-grade regional metamorphism. The triple point is the unique condition where all three minerals coexist in equilibrium. This distribution provides a vital map for understanding the pressure and temperature history of metamorphic terranes.

70. (B) They are framework silicates common in silica-undersaturated rocks.
The epidote group minerals are actually sorosilicates, not framework silicates. Their structure is characterized by both isolated SiO_4 tetrahedra and paired Si_2O_7 groups. They are common in metamorphic rocks, particularly those of the greenschist facies, and are not specifically associated with silica-undersaturated environments. The group includes well-known minerals like epidote, zoisite, and clinozoisite, which are identified by their chemical composition and distinctive physical properties like color.

71. (D) rarity, durability, and beauty.
The distinction between precious and semi-precious stones is based on human valuation rather than purely scientific classification. Precious stones, like diamond, ruby, sapphire, and emerald, are traditionally defined by their exceptional beauty, extreme durability (hardness), and significant rarity. Semi-precious stones may be beautiful but are generally more common or less durable. This classification system is widely used in the gemstone industry to categorize minerals of high economic and aesthetic value.

72. (A) 1, 2, 3, 4
Hardness is a measure of a mineral's resistance to scratching. On the Mohs scale, diamond is the hardest at 10, followed by corundum varieties like ruby and sapphire at 9. Topaz follows with a hardness of 8, and quartz varieties like amethyst are at 7. This standard sequence represents a fundamental property used by geologists and gemologists to identify minerals and evaluate their suitability for various industrial and ornamental applications.

73. (C) iron.
The characteristic green color of most olivine found in nature is primarily due to the presence of ferrous iron (Fe^{2+}) in its crystal structure. While pure magnesium olivine (forsterite) is colorless or white, the substitution of iron into the lattice introduces the greenish hues. As the iron content increases toward the fayalite end-member, the color typically becomes darker, often shifting toward brownish-green or even black in some specimens.

74. (A) Kyanite
Kyanite is the Al_2SiO_5 polymorph that is stable at the highest pressures. Its dense crystal structure makes it the preferred form in high-pressure metamorphic environments, such as those found in subduction zones or the roots of mountain belts. It is easily recognized by its blue color and characteristic bladed crystal habit. The presence of kyanite in a metamorphic rock is a definitive indicator of high-pressure conditions during the rock's formation.

75. (D) Nesosilicates (isolated tetrahedra).
Garnets are classified as nesosilicates because their atomic structure consists of individual SiO_4 tetrahedra that are not directly linked to each other. Instead, these tetrahedra are held together by ionic bonds with divalent and trivalent cations. This isolated arrangement is a fundamental characteristic of the garnet group, influencing its high hardness, lack of cleavage, and the typical formation of equant, dodecahedral crystals in metamorphic and igneous rocks.

76. (A) Both Statement I and Statement II are true.
The olivine group minerals are nesosilicates characterized by isolated silica tetrahedra linked by divalent cations like magnesium and iron. Chlorites are phyllosilicates, or sheet silicates, that typically form through the hydrothermal alteration of primary ferromagnesian minerals like biotite or hornblende. Both statements correctly describe the fundamental structural classification and common geological origin of these two important mineral groups found in many different types of crustal rocks.

77. (C) economic value derived from beauty and durability.
A mineral is classified as a gem or precious stone based on its aesthetic appeal and its ability to withstand wear and tear. Beauty often involves factors like color, clarity, and luster, while durability is largely a function of hardness. These qualities, combined with rarity, create significant economic value. This definition is based on human use and valuation rather than the mineral's chemical formula or its specific mode of geological occurrence.

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78. (D) Sillimanite - Quartz Group
Sillimanite is a polymorph of Al_2SiO_5 and belongs to the aluminosilicate group, not the quartz group. Quartz consists of SiO_2 and includes varieties like amethyst and citrine. Almandine is a member of the garnet group, fayalite belongs to the olivine group, and clinozoisite is part of the epidote group. This mismatch highlights the importance of correctly identifying the chemical and structural relationships that define different mineral groups in mineralogy.

79. (A) the uniform strength of Si-O bonds throughout its framework structure.
Quartz is a framework silicate where every oxygen atom is shared between two silica tetrahedra. The silicon-oxygen bonds are exceptionally strong and are distributed uniformly in all directions throughout the three-dimensional lattice. Because there are no planes of significantly weaker bonding within the structure, quartz does not break along flat surfaces. Instead, it exhibits conchoidal fracture, where the mineral breaks along smooth, curved surfaces similar to glass.

80. (B) Sorosilicate
The epidote group minerals are classified as sorosilicates because their structure contains islands" of silica tetrahedra that occur in both single units (SiO_4) and double units (Si_2O_7). In these double units, two tetrahedra share a single oxygen atom at one corner. This combination of isolated and paired tetrahedra is the defining structural characteristic of the epidote group, distinguishing it from other silicate classes like nesosilicates or inosilicates.

81. (B) It has alternating layers of mica-like and brucite-like sheets.
Chlorite group minerals are phyllosilicates with a complex layered structure. They consist of layers of silica tetrahedra and octahedra, similar to those found in micas, which alternate with independent layers of magnesium and iron hydroxide, known as brucite-like sheets. This stacking sequence is the fundamental structural unit of chlorite. It results in the mineral's characteristic platy habit and perfect basal cleavage, which are typical of many sheet silicate minerals.

82. (A) low pressure and moderate to high temperature.
Andalusite is the Al_2SiO_5 polymorph that is stable at relatively low pressures. It typically forms during contact metamorphism, where rocks are heated by nearby igneous intrusions at shallow depths in the crust. Under these conditions, the low-pressure environment favors the crystal structure of andalusite over its polymorphs, kyanite and sillimanite. It is often identified in metamorphic rocks by its square prismatic crystals and characteristic chiastolite cross.

83. (C) Same chemical formula
Kyanite, andalusite, and sillimanite are polymorphs, which by definition means they share the exact same chemical composition, expressed as Al_2SiO_5. Despite having identical chemistry, they arrange their atoms into different crystal structures depending on the pressure and temperature during formation. This leads to differences in their crystal systems, hardness, cleavage, and overall appearance. Their shared formula is the common thread that links these three important metamorphic minerals together.

84. (D) Corundum
Corundum is an aluminum oxide mineral (Al_2O_3) that is exceptionally hard, second only to diamond. While pure corundum is colorless, trace impurities of chromium produce the red variety known as ruby. Other impurities, such as iron and titanium, result in blue sapphire or other colors of fancy sapphire. Both ruby and sapphire are highly prized as precious gemstones due to their vibrant colors, high luster, and extreme durability in jewelry.

85. (C) Garnet
Garnets are well-known for forming dodecahedral (twelve-sided) or trapezohedral crystals that lack cleavage. They possess a glassy to resinous luster and are quite hard, typically ranging from 6.5 to 7.5 on the Mohs scale. These physical characteristics, combined with their nesosilicate structure, are diagnostic of the garnet group. They are common in metamorphic rocks and can also be found in some igneous rocks, often occurring as distinct, well-formed crystals.

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119. (D) polarized at right angles to each other.
When a beam of light enters an anisotropic mineral, the process of double refraction splits it into two distinct rays. A fundamental requirement of this process is that the two rays must vibrate in planes that are perpendicular to each other. These two plane-polarized rays also travel at different velocities. It is the combination of their perpendicular polarization and their velocity difference that leads to the interference effects observed under a microscope.

120. (A) Interference color
The Michel-Lévy chart is a graphical representation that links three interdependent variables in optical mineralogy: the thickness of the mineral section, the birefringence of the mineral, and the resulting interference color. If any two of these variables are known, the third can be determined from the chart. Most commonly, it is used to find the birefringence of a mineral by observing its maximum interference color in a section of known standard thickness.

121. (C) Chalcophile.
Chalcophile elements are defined by their strong chemical affinity for sulfur rather than oxygen. In Goldschmidt's classification, these elements tend to form sulfide minerals and are often concentrated in sulfide ores. While the Earth's core is primarily siderophile (iron-loving), chalcophile elements are significant in the study of ore deposits and the geochemical differentiation of the Earth's crust and mantle during its early geological history.

122. (A) Beta decay
The radioactive decay of Rubidium-87 to Strontium-87 occurs through beta decay. In this process, a neutron in the Rubidium nucleus spontaneously transforms into a proton and an electron (the beta particle). The electron is emitted, resulting in an increase of the atomic number by one while the atomic mass remains constant. This specific decay scheme is a widely used tool for dating ancient igneous and metamorphic rocks.

123. (A) 1 and 2 only
A geochemical cycle tracks the movement of elements through the Earth's reservoirs, including the crust, mantle, oceans, and atmosphere. The rock cycle is a key part of this, moving elements through igneous, sedimentary, and metamorphic processes. However, human activities, such as mining and fossil fuel combustion, significantly influence these cycles by altering the distribution and concentration of many elements, making the third statement in the question incorrect.

124. (B) Oxygen and Silicon
Oxygen and silicon are by far the two most abundant elements in the Earth's crust, together making up approximately 75% of its total weight. Oxygen is the most abundant, typically occurring as anions in silicate and oxide minerals, while silicon is the second most abundant, forming the backbone of the silicate mineral group. These two elements are the primary building blocks of most common rock-forming minerals.

125. (C) the conservation of energy.
The First Law of Thermodynamics states that energy cannot be created or destroyed, only transformed from one form to another. In geochemical systems, this means the total energy of a system and its surroundings remains constant throughout any process. This principle is fundamental for calculating heat changes and work performed during chemical reactions, phase transformations, and the cooling of magmas within the Earth's interior.

126. (A) Both A and R are true and R is the correct explanation of A.
The K-Ar dating method is based on the decay of Potassium-40 to Argon-40. Because argon is a gas, it is easily trapped in cooling volcanic rocks, but it can also be easily lost if the rock is reheated. This loss resets" the radiometric clock, making the method useful for dating the most recent cooling event. This sensitivity to heating explains both the utility and the limitations of the K-Ar system.

127. (A) are 'rock-loving' and concentrate in the silicate crust.
Lithophile elements are those that have a strong affinity for oxygen and are readily incorporated into silicate minerals. In Goldschmidt's geochemical classification, these elements are termed rock-loving" because they are concentrated in the silicate-rich crust and mantle of the Earth. Common examples include silicon,

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94. (D) The numerical difference between the highest and lowest refractive indices of an anisotropic mineral.
Birefringence is a quantitative measure of the degree of double refraction in an anisotropic mineral. It is calculated as the absolute difference between the maximum and minimum refractive indices of the crystal. This property determines the intensity and order of interference colors seen under crossed polarizers. Higher birefringence values result in more vibrant, higher-order interference colors, which are essential for identifying minerals like calcite or olivine under the microscope.

95. (A) Isotropic.
Minerals that crystallize in the isometric (cubic) system possess the highest degree of symmetry. Because of this uniform internal structure, light travels at the same velocity in every direction through the crystal. This means there is only one refractive index and no splitting of light rays. In optical mineralogy, such minerals are termed isotropic and always appear dark when viewed under crossed polarizers on a petrographic microscope stage.

96. (A) Both A and R are true and R is the correct explanation of A.
Isotropic minerals do not exhibit double refraction, meaning they do not split incident light into two rays. When plane-polarized light enters an isotropic crystal, its vibration direction remains unchanged. As this light reaches the upper polarizer (analyzer), which is oriented perpendicular to the lower polarizer, it is completely blocked. Consequently, the mineral appears dark or extinct in all orientations, which is a diagnostic feature of isometric minerals.

97. (B) It involves splitting a single light ray into an ordinary ray (O-ray) and an extraordinary ray (E-ray).
Double refraction occurs in anisotropic minerals, where an incident light ray is divided into two separate components. In uniaxial minerals, these are the ordinary ray, which follows standard refraction laws, and the extraordinary ray, whose velocity varies with direction. These two rays vibrate in mutually perpendicular planes and travel at different speeds. This fundamental phenomenon is responsible for the interference colors observed when minerals are viewed between crossed polarizing filters.

98. (A) Isotropic and Anisotropic
In optical mineralogy, minerals are first categorized into two primary groups based on their symmetry and effect on light. Isotropic minerals, belonging to the isometric system, have uniform optical properties in all directions. Anisotropic minerals, belonging to all other crystal systems, exhibit properties that vary with crystallographic direction, such as refractive index and light velocity. This basic division is the starting point for all further optical identification and classification procedures.

99. (A) P-3, Q-4, R-2, S-1
The refractive index measures light's speed reduction in a medium. Birefringence is the mathematical difference between the extreme refractive indices. Pleochroism describes the change in color as a mineral is rotated in plane-polarized light. Double refraction is the actual physical splitting of light into two rays. These definitions form the core vocabulary of optical mineralogy and are essential for accurately describing and identifying minerals using a petrographic microscope.

100. (D) Radioactive decay
Refraction, polarization, and double refraction are all fundamental principles of physical optics used to study the behavior of light within minerals. Refraction describes light bending, polarization refers to the orientation of light vibrations, and double refraction is the splitting of rays in anisotropic crystals. Radioactive decay, however, is a nuclear process involving the spontaneous transformation of atomic nuclei and is unrelated to the optical properties of minerals.

101. (C) Anisotropic.
When a mineral displays interference colors under crossed polarizers, it must be splitting the polarized light into two rays that travel at different speeds. This phenomenon only occurs in anisotropic minerals, which include those in all crystal systems except the isometric. The interaction of these two rays as they emerge from the crystal creates the characteristic colors. Isotropic minerals, by contrast, would remain dark because they do not split light.

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102. (B) how much the speed of light is reduced as it passes through the mineral.
The refractive index of a mineral is a dimensionless number defined as the ratio of the speed of light in a vacuum to its speed within the mineral. Since light always travels slower in a solid medium than in a vacuum, the refractive index is always greater than one. This value indicates how much light is bent upon entry and is a fundamental property used to distinguish different mineral species.

103. (D) Isometric
Only minerals in the isometric (cubic) crystal system are optically isotropic. In these minerals, the internal arrangement of atoms is so highly symmetrical that light moves at the same velocity regardless of the direction it travels. This uniformity results in a single refractive index. Minerals in the tetragonal, orthorhombic, and monoclinic systems have lower symmetry, causing light velocities to vary with direction, which makes them optically anisotropic.

104. (A) the microscope stage is lowered or the focal distance is increased.
The Becke line is a band of light that appears at the interface between a mineral and the surrounding medium. When the distance between the objective lens and the sample is increased by lowering the stage, the Becke line always moves toward the material with the higher refractive index. This reliable movement allows geologists to compare the mineral's index to a known oil, aiding in the identification of the mineral.

105. (C) the order of interference colors.
Birefringence is the difference between the maximum and minimum refractive indices of a mineral, and it directly determines the retardation of light rays. This retardation is expressed visually as interference colors when viewed under crossed polarizers. By observing the color and identifying its position on the Michel-Lévy chart, a geologist can qualitatively estimate the birefringence of the mineral, which is a key diagnostic feature for identification.

106. (A) It is constrained to vibrate in a single plane.
The lower polarizer of a petrographic microscope is a filter that only allows light waves vibrating in a specific direction to pass through. When unpolarized light, which vibrates in all directions, enters this filter, only the component of light vibrating parallel to the filter's transmission axis emerges. This resulting light is called plane-polarized light, which is essential for observing properties like pleochroism and interference colors in minerals.

107. (A) Both Statement I and Statement II are true.
In uniaxial anisotropic minerals, the ordinary ray travels at a constant velocity in all directions and follows Snell's law of refraction. The extraordinary ray, however, has a velocity that depends on its direction of travel relative to the crystal's optic axis. Because its speed changes, its path does not strictly obey Snell's law. Both statements correctly describe the fundamental behavior of these two light rays as they propagate through anisotropic crystals.

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108. (B) uniaxial and biaxial groups.
Anisotropic minerals are further classified based on the number of optic axes they possess. Uniaxial minerals, belonging to the tetragonal and hexagonal systems, have a single optic axis. Biaxial minerals, belonging to the orthorhombic, monoclinic, and triclinic systems, have two optic axes. This distinction is determined by the crystal's symmetry and is a primary step in the systematic optical identification of minerals under a polarizing microscope.

109. (C) Garnet
Garnet is a member of the isometric crystal system, which means its internal structure is highly symmetrical. This symmetry ensures that light travels at the same speed in all directions, making the mineral optically isotropic. Quartz, calcite, and orthoclase belong to non-isometric systems and are therefore anisotropic. Under crossed polarizers, a garnet grain will remain dark as it is rotated, which is a diagnostic feature for identifying isometric minerals.

110. (D) Calcite (Iceland Spar).
Iceland Spar is a famously clear variety of calcite that exhibits exceptionally high birefringence. When a piece of this clear calcite is placed over a line or text, the double refraction is so strong that two distinct images are visible. This occurs because the light is split into two rays that are widely separated due to the large difference between the mineral's refractive indices. It is

the classic example used to demonstrate double refraction.

111. (A) Birefringence.
Interference colors are produced by the phase difference, or retardation, between the two rays traveling through an anisotropic mineral. This retardation is the product of the mineral's thickness and its birefringence. If the thickness is constant, such as in a standard thin section, the interference color depends entirely on the birefringence. This allows geologists to identify minerals by comparing their observed colors to the Michel-Lévy chart.

112. (B) Uniaxial.
Minerals in the tetragonal and hexagonal systems have a single direction of high symmetry, known as the c-axis, which also serves as the single optic axis. Because they possess only one optic axis, they are classified as uniaxial. This symmetry distinguishes them from isometric minerals, which are isotropic, and from minerals in the orthorhombic, monoclinic, and triclinic systems, which have two optic axes and are therefore classified as biaxial.

113. (B) the degree to which a mineral grain stands out from its mounting medium.
Relief is an optical effect caused by the difference in refractive index between a mineral and the medium surrounding it, such as an immersion oil or Canada balsam. Minerals with a refractive index much higher or lower than the medium will have dark, distinct borders and appear to stand out." Those with indices close to the medium will have faint borders and appear low" in relief.

114. (A) low relief.
When the refractive index of a mineral is nearly the same as the refractive index of the mounting medium, light passes through the boundary with very little refraction or reflection. As a result, the grain boundaries appear faint or nearly invisible under the microscope. This condition is described as low relief. High relief occurs when there is a significant difference between the mineral's refractive index and that of the surrounding medium.

115. (C) 45°
An anisotropic mineral shows its maximum interference color intensity when its vibration directions are at 45° to the vibration directions of the microscope's polarizer and analyzer. At this orientation, the polarized light entering the mineral is resolved into two components of equal amplitude, which then recombine to produce the strongest interference effect. If the vibration directions are parallel to the polars (0° or 90°), the mineral appears extinct.

116. (D) extinction.
Extinction occurs when an anisotropic mineral's vibration directions are aligned parallel to the vibration directions of the polarizer and analyzer. In this position, no light can pass through the upper polar, and the mineral appears dark. For isotropic minerals, they are always in extinction because they do not split or rotate the polarized light. The angle at which extinction occurs is often a useful property for identifying specific minerals in thin sections.

117. (C) To provide a medium of known refractive index for comparison.
Immersion oils are essential tools in optical mineralogy for determining the refractive index of mineral fragments. By placing a mineral in an oil with a precisely known index, a geologist can use the Becke line test to see if the mineral's index is higher or lower than the oil. By using a series of oils, the mineral's exact refractive index can be bracketed and determined, which is critical for identification.

118. (B) Birefringence is a property of isotropic minerals.
Birefringence is defined as the difference between the refractive indices in an anisotropic mineral. Isotropic minerals, by definition, have only one refractive index because light travels at the same speed in all directions through their highly symmetrical structure. Therefore, the difference between indices is zero, and they cannot possess birefringence. This property is exclusive to anisotropic minerals, which belong to the tetragonal, hexagonal, orthorhombic, monoclinic, and triclinic crystal systems.

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152. (C) Aragonite group
The aragonite group consists of anhydrous carbonate minerals that follow the RCO_3 formula and crystallize in the orthorhombic system. Aragonite itself is the most common member and is a polymorph of calcium carbonate. Other members include strontianite and witherite. This group is distinguished from the calcite group, which is trigonal. The larger size of the cations in most aragonite group members favors the orthorhombic structure over the trigonal one found in calcite.

153. (A) 1:4
In nesosilicates, also known as orthosilicates, the silica tetrahedra are completely isolated from each other. This means that no oxygen atoms are shared between adjacent tetrahedra. As a result, each silicon atom is bonded to four unique oxygen atoms, giving a fundamental Si:O ratio of 1:4. This structural unit is represented by the SiO_4 anion and is characteristic of minerals like olivine, garnet, and zircon, where metallic cations provide the overall charge balance.

154. (D) exsolution.
Exsolution is the process that occurs when a solid solution becomes unstable at lower temperatures and separates into two distinct mineral phases. In alkali feldspars, a homogeneous mixture of sodium and potassium exists at high temperatures. Upon slow cooling, the different sized ions can no longer fit in the same lattice, and they unmix into separate sodium-rich and potassium-rich layers. This often results in the visible perthitic texture commonly observed in many granitic rocks.

155. (A) Both A and R are true and R is the correct explanation of A.
The calcite group minerals crystallize in the trigonal system and are famous for their perfect rhombohedral cleavage. This physical property is a direct result of the crystal structure, where the chemical bonds between layers of atoms are significantly weaker in certain directions. When the mineral is struck, it breaks cleanly along these planes of weakness, producing the characteristic rhombohedral fragments. This relationship between atomic structure and physical cleavage is fundamental to mineral identification.

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156. (C) Spinel group (XY_2O_4)
The spinel group consists of oxide minerals that follow the general chemical formula XY_2O_4, where X is a divalent cation and Y is a trivalent cation. They crystallize in the isometric system and include important industrial and rock-forming minerals like magnetite, chromite, and spinel itself. This group is distinct from other oxide groups like rutile or hematite, which have different cation-to-oxygen ratios and structural arrangements of their respective metal and oxygen atoms.

157. (D) Molecular water (H_2O)
Sulfate minerals are divided into anhydrous and hydrous types based on whether their crystal structure incorporates water molecules. Anhydrous sulfates, like barite and anhydrite, contain only metal cations and the sulfate anion. Hydrous sulfates, such as gypsum, contain specific amounts of molecular water (H_2O) trapped within the lattice. This water is an essential part of the chemical formula and significantly influences the mineral's physical properties, such as its hardness and specific gravity.

158. (A) P-3, Q-1, R-2, S-4
Galena and sphalerite are both classic AX type sulfides, though they have different crystal structures (halite vs. sphalerite structure). Pyrite follows the AX2 formula, where sulfur occurs in pairs. Chalcocite is an example of the A2X type, with two copper atoms for every sulfur. These structural classifications are based on the stoichiometric ratio of cations to anions, which is a primary method for organizing the sulfide mineral class in systematic mineralogy and petrography.

159. (B) They are double carbonates with two different cation sites.
The dolomite group minerals are double carbonates with the general formula $AB(CO_3)_2$, where A and B represent different divalent cations like calcium, magnesium, iron, or manganese. In their trigonal structure, these different cations are organized into alternating, ordered layers. This ordering is a key characteristic that distinguishes the dolomite group from the simple carbonates of the calcite group, and it leads to a lower degree of symmetry in their overall crystal form.

aluminum, magnesium, calcium, and the alkali metals, which together form the vast majority of the minerals found in common rocks.

128. (B) U-Pb
The U-Pb dating system is unique because it involves a long, complex decay series rather than a single-step transformation. Uranium isotopes (U-238 and U-235) undergo a sequence of multiple alpha and beta decay events before reaching stable lead isotopes (Pb-206 and Pb-207). In contrast, schemes like Rb-Sr, K-Ar, and Sm-Nd are simpler, involving only a single radioactive decay step to reach their respective daughter products.

129. (A) movement and transformation of chemical elements through the Earth's spheres.
The geochemical cycle refers to the continuous movement and recycling of chemical elements between the Earth's major reservoirs, including the lithosphere, hydrosphere, atmosphere, and biosphere. It encompasses all the processes—such as weathering, sedimentation, subduction, and volcanism—that redistribute elements over geologic time. Understanding these cycles is fundamental for grasping the distribution of resources and the long-term chemical evolution of the planet's surface and interior.

130. (C) leads to a decrease in the Gibbs Free Energy of the system.
According to the principles of thermodynamics, a chemical reaction will occur spontaneously at constant temperature and pressure only if it leads to a reduction in the Gibbs Free Energy (G). The system naturally moves toward a state of lower energy and higher stability. Therefore, the direction of any spontaneous geochemical process, such as mineral precipitation or metamorphic reaction, is always toward the state with the minimum available Gibbs Free Energy.

131. (A) 2, 4, 3, 1
The internal structure of the Earth is divided into distinct layers based on chemical and physical properties. From the center moving outward, the sequence begins with the solid inner core, followed by the liquid outer core. Next is the thick, silicate mantle, and finally the thin, outermost crust. This arrangement reflects the differentiation of the planet early in its history, with the densest materials settling at the center.

132. (C) Electron capture
Potassium-40 undergoes a branched decay, where approximately 11% of the atoms transform into Argon-40. This specific pathway occurs through electron capture, where a proton in the nucleus captures an inner-shell electron and becomes a neutron. This decreases the atomic number by one while the atomic mass remains the same. The remaining 89% of Potassium-40 decays to Calcium-40 through beta emission, but it is the K-Ar branch that is useful for dating.

133. (B) Atmophile
Atmophile elements are those that are volatile and tend to exist in the gaseous state under normal surface conditions. In Goldschmidt's classification, this group includes hydrogen, nitrogen, carbon (as CO2), and all the noble gases like helium and argon. These elements are primarily concentrated in the atmosphere and the hydrosphere, having been largely excluded from the solid silicate and metallic phases during the Earth's early differentiation.

134. (D) Zircon
Zircon is the preferred mineral for U-Pb dating because of its unique chemical properties. When zircon crystallizes from a magma, its crystal structure easily accommodates uranium atoms but strongly rejects lead. Therefore, any lead found in a pristine zircon crystal can be assumed to have been produced by the radioactive decay of uranium since the time of crystallization. Zircon is also extremely durable and resistant to chemical weathering and metamorphism.

135. (A) The core is predominantly composed of iron and nickel.
Based on seismic data and the study of meteorites, the Earth's core is inferred to be composed primarily of an iron-nickel alloy, making it the planet's densest layer. The crust and mantle, while both being silicate-rich, have different chemical compositions; the mantle is more enriched in magnesium and iron. Silicon is very abundant in the crust, but iron is actually the most abundant element in the Earth as a whole.

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136. (C) Alpha decay.
The decay of Samarium-147 to Neodymium-143 is a radioactive process that occurs through the emission of an alpha particle. An alpha particle consists of two protons and two neutrons. This emission reduces the atomic mass by four units and the atomic number by two. The Sm-Nd dating system is particularly valuable for studying the early history of the Earth's mantle and crust due to the high stability of these elements during geological processes.

137. (A) minimum order and maximum entropy.
The Second Law of Thermodynamics states that in any spontaneous process, the total entropy of an isolated system must increase over time. Entropy is a measure of the disorder or randomness in a system. Therefore, natural geochemical processes tend to move from a state of higher order (lower entropy) to a state of greater disorder (higher entropy). This principle explains why energy spreads out and systems reach thermal and chemical equilibrium.

138. (D) Au - Atmophile
Gold (Au) is classified as a siderophile (iron-loving) or chalcophile (sulfur-loving) element, but certainly not as an atmophile. Atmophile elements are volatile gases like nitrogen and the noble gases. In Goldschmidt's system, oxygen is a lithophile, iron is the primary siderophile, and sulfur is the primary chalcophile. This classification reflects where each element is likely to be concentrated during the chemical differentiation of a planet or within a meteorite system.

139. (B) The rock has remained a closed system with respect to Rb and Sr since its formation.
For any radiometric date to be accurate, the geologist must assume that no parent atoms (Rb) or daughter atoms (Sr) have been added to or removed from the rock except through radioactive decay. This is the closed system" assumption. If the rock was reheated or chemically altered, it might have lost some of these atoms, leading to an incorrect age. This fundamental principle applies to nearly all geochronological dating methods used in geology.

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140. (C) the distribution and concentration of elements in the Earth systems.
The concept of the geochemical cycle is fundamental for understanding how elements are redistributed and concentrated across the Earth's various reservoirs over time. It links processes like weathering, subduction, and magmatism into a single integrated framework. By studying these cycles, geoscientists can explain why certain elements are common in the crust while others are concentrated in the core or the oceans, which is essential for resource discovery.

141. (D) Iron and Magnesium.
The Earth's mantle is primarily composed of ultramafic rocks like peridotite, which are significantly richer in iron and magnesium compared to the more felsic or intermediate rocks of the crust. While the crust contains more silicon, aluminum, sodium, and potassium, the mantle represents a much larger reservoir of the Earth's ferromagnesian components. This chemical difference is a result of the early differentiation of the Earth into a core, mantle, and crust based on density.

142. (A) Sm-Nd
The Sm-Nd dating system involves two elements, samarium and neodymium, which both belong to the rare earth element (REE) group. Rare earth elements have very similar chemical properties and are often found together in nature. Because they are relatively resistant to being moved by weathering or low-grade metamorphism, the Sm-Nd system is highly valued for dating very old rocks and for tracing the geochemical evolution of the Earth's mantle and crust over billions of years.

143. (B) 'iron-loving'.
The term 'siderophile' is derived from the Greek words for 'iron' and 'loving'. These elements have a high chemical affinity for metallic iron and tend to dissolve in it. In Goldschmidt's geochemical classification, siderophile elements like nickel, cobalt, and the platinum group metals are primarily concentrated in the Earth's core. Their relative scarcity in the Earth's crust is due to them being pulled into the core during the planet's early differentiation when it was molten.

144. (B) The time it takes for half of the parent atoms to decay.
Half-life is a fundamental constant in radioactive decay that defines the rate at which a parent isotope transforms into its daughter product. It is the specific amount of time required for exactly 50% of the initial number of radioactive atoms in a sample to undergo decay. This rate is independent of physical conditions like temperature or pressure, providing a reliable clock" for measuring the vast timescales of geological history through various radiometric dating techniques.

145. (A) an open system.
In thermodynamics, an open system is one that can freely exchange both energy (in the form of heat or work) and matter with its surroundings. Most natural geochemical systems, such as a river, a volcano, or a weathering soil profile, are open systems. In contrast, a closed system can exchange energy but not matter, and an isolated system can exchange neither. Identifying the type of system is crucial for applying thermodynamic laws correctly.

146. (C) Chalcophile.
While gold and platinum group metals have siderophile tendencies, they are also frequently classified as chalcophile because they show a strong affinity for sulfur in many geological environments. They are often found concentrated in sulfide ore deposits. In the specific context of Goldschmidt's classification based on meteorite phases, these elements are often grouped with chalcophiles due to their behavior in sulfide-rich systems, though they share characteristics with siderophile elements depending on the specific conditions.

147. (D) biology.
Modern geochemistry recognizes that life plays a significant role in the movement and transformation of many elements, such as carbon, nitrogen, and phosphorus. Biogeochemical cycles describe how these elements cycle through the biological, geological, and chemical components of the Earth. Therefore, the concept of a geochemical cycle is truly interdisciplinary, integrating principles from geology, chemistry, and biology to provide a complete picture of how the Earth's surface environment evolves and sustains life.

148. (C) carbonaceous chondrites.
Carbonaceous chondrites are a group of primitive stony meteorites that are believed to represent the original, undifferentiated material from which the solar system and the Earth formed. Their chemical composition closely matches the composition of the Sun's photosphere (excluding volatile gases). Geochemists use the elemental ratios found in these meteorites as a standard for the bulk Earth" composition, allowing them to calculate how elements have been redistributed into the core, mantle, and crust.

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149. (B) The law of conservation of energy.
The First Law of Thermodynamics is the law of conservation of energy, which states that the total energy of an isolated system remains constant. It can be transformed from one form to another, such as chemical energy into heat, but it cannot be created or destroyed. This is a fundamental law used throughout science, including geochemistry, to track the energy changes that occur during geological processes like the melting and crystallization of rocks.

150. (D) Magnetite (Fe_3O_4)
Magnetite is an oxide mineral, not a sulfide, as indicated by its chemical formula Fe_3O_4. Sulfide minerals are those that contain the sulfur anion (S^{2-}). Galena, sphalerite, and pyrite are all classic examples of sulfide minerals. Magnetite belongs to the spinel group of oxides and is known for its strong magnetic properties. Distinguishing between these classes is a fundamental task in mineral identification based on their chemical composition and bonding.

151. (A) Both Statement I and Statement II are true.
Isomorphism allows minerals with different chemistry but the same structure to form a continuous solid solution, where ions substitute for each other. Polymorphism describes the opposite case, where a single chemical compound can exist in multiple crystal structures depending on the physical conditions. Both phenomena are fundamental to mineralogy and explain the vast diversity and chemical variability of the minerals that make up the Earth's crust and mantle in various environments.

86. (B) Forsterite (Mg_2SiO_4).
Forsterite is the end-member of the olivine solid-solution series that contains only magnesium as the divalent cation, resulting in the chemical formula Mg_2SiO_4. It is an essential mineral in ultramafic rocks and the primary component of the Earth's upper mantle. While fayalite is the iron end-member, enstatite and ferrosilite are members of the pyroxene group. Forsterite is often identified by its high melting point and characteristic light green color.

87. (D) Amethyst
Amethyst is a purple variety of quartz and is traditionally classified as a semi-precious stone. While it is very beautiful and popular in jewelry, it is much more abundant and less expensive than the four traditional precious" stones: diamond, ruby, sapphire, and emerald. This distinction is based on the rarity and market value of the minerals, although amethyst remains one of the most highly valued and recognized semi-precious gemstones worldwide.

88. (A) high temperature.
Sillimanite is the polymorph of Al_2SiO_5 that is stable at the highest temperatures. It is a characteristic mineral of high-grade metamorphic rocks, such as gneisses and schists, where intense heat has caused the restructuring of aluminosilicate minerals. While kyanite is the high-pressure form and andalusite is the low-pressure form, sillimanite's appearance in a rock indicates that it has reached the highest levels of metamorphic heating during its geological history.

89. (C) They are common in felsic igneous rocks like granite.
Olivine group minerals are characteristic of mafic and ultramafic igneous rocks, such as basalt, gabbro, and peridotite. They are rarely found in felsic rocks like granite because granite is typically silica-oversaturated and contains quartz. Olivine and quartz are generally chemically incompatible in igneous systems. Olivine is a major component of the Earth's mantle and is distinguished by its nesosilicate structure, high specific gravity, and lack of prismatic cleavage.

90. (A) Pyroxenes, amphiboles, and biotite
Chlorite is a common secondary mineral that forms through the alteration of ferromagnesian silicates like pyroxenes, amphiboles, and biotite. This process, often involving hydrothermal fluids or low-grade metamorphic conditions, breaks down the original minerals and reorganizes their magnesium, iron, and aluminum into the layered sheet structure of chlorite. This transformation is a classic example of mineral alteration and is responsible for the green color seen in many altered igneous rocks.

91. (D) anisotropic minerals only.
Double refraction is an optical property unique to anisotropic minerals, which include all crystal systems except the isometric system. When light enters an anisotropic crystal, it is split into two rays that travel at different velocities and vibrate in perpendicular planes. Isotropic minerals, like those in the isometric system or amorphous materials, have the same light velocity in all directions and therefore do not exhibit this phenomenon of ray splitting.

92. (B) Refractive Index relative to the mounting medium.
The Becke line test is a fundamental technique in optical mineralogy used to determine whether a mineral grain has a higher or lower refractive index than the surrounding immersion oil. By observing the movement of a bright line of light at the grain boundary as the microscope stage is lowered, the geologist can determine the relative refractive index. This information is crucial for identifying unknown minerals in grain mounts or thin sections.

93. (A) 1 and 2 only
Isotropic minerals, belonging to the isometric system, have a single refractive index and do not split light. Anisotropic minerals, belonging to all other crystal systems, are characterized by double refraction, where light is split into two rays. However, double refraction is not a property of all crystalline solids, as isometric crystals are an exception. Therefore, only the first two statements are correct descriptions of the basic optical behavior of minerals.

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160. (A) Phyllosilicates (Sheets)
Phyllosilicates, or sheet silicates, are characterized by two-dimensional layers of silica tetrahedra. In these layers, each tetrahedron shares three of its oxygen atoms with neighboring tetrahedra. This arrangement results in a fundamental silicon to oxygen ratio of 2:5, often expressed as Si_4O_{10} in mineral formulas. This structural pattern is the defining feature of common mineral groups like the micas, chlorites, and clays, and it explains their characteristic platy habit and cleavage.

161. (A) alkali feldspar that cooled slowly.
Perthitic texture consists of lamellae of albite (sodium-rich) within a host of potassium-rich feldspar. This texture is the product of exsolution, which occurs when a homogeneous alkali feldspar cools slowly enough for the sodium and potassium ions to separate into distinct phases. Rapid cooling would trap the ions in a metastable solid solution, preventing the formation of these visible intergrowths. Therefore, perthite is a definitive indicator of slow cooling in granitic igneous rocks.

162. (C) they are unstable in the presence of free silica (quartz).
Feldspathoids are chemically similar to feldspars but contain a lower proportion of silica. They only form in magmas where there is not enough silica to produce more common framework minerals. If free silica were present, it would react with the feldspathoids to form feldspar minerals. For example, nepheline reacts with silica to form albite. This chemical incompatibility explains why feldspathoids and quartz are never found together in equilibrium in a natural igneous rock.

163. (D) Amphibole
The presence of the hydroxyl (OH) radical is a fundamental requirement for the crystal structure of all amphiboles. These minerals are double-chain inosilicates that contain a specific lattice site which must be filled by hydroxyl ions, fluorine, or chlorine. While pyroxenes are also inosilicates, they have a single-chain structure that is typically anhydrous. This chemical difference is a primary diagnostic feature used to distinguish these two major mineral groups from one another in geochemistry.

164. (C) arrangement of silica tetrahedra into chains.
The characteristic cleavage angles of pyroxenes and amphiboles are directly caused by their internal silicate structures. Pyroxenes consist of single chains of tetrahedra, leading to cleavage planes that intersect at nearly 90 degrees. Amphiboles consist of double chains, which are wider and result in different planes of weakness that intersect at approximately 124° and 56°. Observing these angles is the standard way to distinguish between these minerals in both hand specimens and thin sections.

165. (B) mica group.
The mica group, including muscovite and biotite, is characterized by its sheet silicate structure. The atoms within each sheet are held together by very strong covalent and ionic bonds, while the sheets themselves are linked by much weaker bonds through interlayer cations. This structural arrangement results in perfect basal cleavage, which allows the mineral to be easily split into extremely thin, flexible, and elastic sheets. This is the most distinctive physical property of the mica group.

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166. (D) An open framework structure that allows for reversible dehydration.
Zeolites are tectosilicates with a uniquely open three-dimensional framework of silica and alumina tetrahedra. This framework contains large, interconnected channels and cavities that host water molecules and exchangeable cations. Because the bonds in the framework are very strong, the water can be removed by heating and then regained without collapsing the crystal lattice. This property of reversible dehydration, along with ion-exchange capability, defines the zeolite group and makes them useful in many industrial applications.

167. (A) Albite and Anorthite
The plagioclase feldspar series is a continuous solid solution between the sodium end-member, albite ($NaAlSi_3O_8$), and the calcium end-member, anorthite ($CaAl_2Si_2O_8$). These two minerals have the same framework structure but vary in their proportions of sodium, calcium, silicon, and aluminum. The entire plagioclase series is classified based on the relative percentage of these two end-members, which influences

the mineral's optical properties and its specific occurrence in different types of igneous rocks.

168. (C) A single chain of silica tetrahedra.
Pyroxenes are classified as single-chain inosilicates. Their fundamental structural unit is a continuous string of silica tetrahedra, where each tetrahedron shares two of its oxygen atoms with its neighbors. These chains are linked together by various metallic cations to form the overall crystal structure. This single-chain arrangement is the primary structural difference between pyroxenes and other silicate groups, such as the double-chain amphiboles or the sheet-like micas, and it determines their characteristic cleavage.

169. (A) They are all chemically simple, with no solid solution.
Feldspars are not chemically simple; they exhibit extensive solid solution among three main end-members: orthoclase, albite, and anorthite. These form two major series: the alkali feldspars and the plagioclase feldspars. This chemical variability allows feldspars to incorporate potassium, sodium, and calcium in various proportions. The statement that they have no solid solution is incorrect, as these solid solutions are fundamental to their classification and their role as the most abundant minerals in the Earth's crust.

170. (D) feldspathoid.
Feldspathoids are a group of aluminosilicate minerals that are chemically similar to feldspars but contain significantly less silica. They form instead of feldspars in magmas that are deficient in silicon. Common examples include nepheline and leucite. Because they require low-silica conditions, they are never found in equilibrium with quartz. In this way, they serve as the silica-undersaturated analogues to the more common framework feldspar minerals found in most other types of igneous rocks.

171. (B) Iron and Magnesium
Both biotite and muscovite belong to the mica group and share a sheet silicate structure. However, biotite is a ferromagnesian mica, meaning its structure contains significant amounts of iron and magnesium in the octahedral sites. These elements give biotite its characteristic dark brown to black color and high specific gravity. Muscovite, in contrast, lacks these ferromagnesian elements and is rich in aluminum and potassium, resulting in its light-colored or silvery-white appearance in hand specimens.

172. (C) Nesosilicates
The garnet group minerals are classified as nesosilicates, or orthosilicates, because their atomic structure is based on isolated silica tetrahedra (SiO_4 units). These tetrahedra are not linked to each other but are instead held in a framework by ionic bonds with various divalent and trivalent cations. This isolated structural arrangement is responsible for the garnets' characteristic high density, high hardness, and their tendency to form equant, dodecahedral crystals in metamorphic and igneous rocks.

173. (D) kyanite, andalusite, and sillimanite can all exist in stable equilibrium.
The triple point in the Al_2SiO_5 system is the specific temperature and pressure at which the stability fields of all three polymorphs—kyanite, andalusite, and sillimanite—meet. At this unique point, all three minerals can coexist in stable equilibrium. This point is a crucial reference in metamorphic petrology for calibrating geothermobarometers and for understanding the specific physical conditions that a rock underwent during the processes of mountain building and crustal metamorphism over geologic time.

174. (A) They are nesosilicates forming a solid solution series between forsterite and fayalite.
The olivine group consists of minerals with an isolated silicate tetrahedra structure (nesosilicates). They form a continuous solid solution series between the magnesium end-member, forsterite, and the iron end-member, fayalite. Olivine is the most abundant mineral in the Earth's upper mantle and is characteristic of mafic and ultramafic rocks. It is recognized by its glassy luster, high hardness, and typically green color, and it rarely coexists with quartz due to chemical incompatibility in magmas.

175. (B) Green Garnet
Green garnet, such as tsavorite or demantoid, belongs to the garnet group of minerals and is not a variety of quartz. Quartz varieties are all composed of SiO_2 and include minerals

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like smoky quartz, rose quartz, and tiger's eye. Garnets are nesosilicates with a much more complex chemical formula and a different crystal structure. This distinction is important in gemology and mineralogy because the two groups have very different physical properties, chemical compositions, and geological origins.

176. (B) both isolated (SiO_4) and paired (Si_2O_7) tetrahedral groups.
The epidote group is classified as a sorosilicate because its crystal structure is built from a combination of isolated silica tetrahedra (SiO_4) and paired tetrahedra (Si_2O_7). In the paired units, two tetrahedra share a single oxygen atom at one corner to form a bowtie" shape. This complex arrangement of tetrahedra is the defining feature of the epidote structure. It results in the group's characteristic physical properties and its common occurrence in metamorphic and altered igneous rocks.

177. (A) green color and platy habit.
Chlorite is a common mineral in low-grade metamorphic rocks, such as greenschists, and is also a frequent product of hydrothermal alteration. It is characterized by its distinctive green color, which is caused by its high iron and magnesium content. Structurally, it is a phyllosilicate, meaning it forms thin, plate-like crystals and exhibits perfect basal cleavage. These features make it relatively easy to identify in both hand specimens and under the microscope in rock sections.

178. (C) Beauty, durability, and rarity
The term precious stone" is traditionally reserved for gemstones that possess three essential qualities: exceptional beauty, high durability, and extreme rarity. Beauty is typically evaluated based on color, clarity, and luster. Durability is a function of the mineral's hardness and resistance to chemical change, which ensures it can be worn in jewelry for generations. Rarity ensures that the stone remains valuable. Diamond, ruby, sapphire, and emerald are the classic examples of precious stones.

179. (D) Kyanite.
Kyanite is the Al_2SiO_5 polymorph that is stable at high pressures. It is common in regional metamorphic rocks like schists and gneisses that formed deep within the crust. It is uniquely characterized by its bladed crystal habit and its distinct blue color. Interestingly, kyanite also exhibits a significant variation in hardness depending on the direction in which it is scratched, a property known as allotropism. This makes it easily recognizable to geologists and mineralogists in the field.

180. (C) Beryl
Emerald is the highly prized, green variety of the mineral beryl ($Al_2Be_3Si_6O_{18}$). The distinctive green color is typically caused by trace amounts of chromium or sometimes vanadium substituting into the crystal lattice. Other gem varieties of beryl include the blue aquamarine and the pink morganite. Beryl is a cyclosilicate mineral that forms hexagonal crystals and is characterized by its high hardness, making it ideal for use in high-end jewelry and as a collectors' gemstone.

181. (B) Olivine.
Olivine is commonly recognized by its granular appearance and its characteristic bottle-green to yellowish-green color. Under the microscope, it typically shows high relief and lacks cleavage, instead exhibiting irregular fractures. It is a nesosilicate that is a primary constituent of ultramafic and mafic igneous rocks. While minerals like augite or hornblende might be green, their cleavage and different structural classifications distinguish them from the distinctively granular and high-relief grains typical of the olivine mineral group.

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182. (A) 1 and 2 only
Kyanite, andalusite, and sillimanite are indeed all polymorphs of Al_2SiO_5, sharing the same chemistry. Their stability fields are well-defined by pressure and temperature, making them excellent indicators of metamorphic conditions. However, sillimanite is the high-temperature polymorph, whereas andalusite is the polymorph stable at low pressures. Therefore, the third statement in the question is incorrect. These minerals are vital tools for geologists to reconstruct the geological history and tectonic evolution of metamorphic terranes worldwide.

183. (A) isotropic and anisotropic minerals.
The primary division in the optical classification of minerals is between those that are isotropic

being split. This behavior is a direct consequence of the mineral's crystal system and symmetry.

229. (B) the number of optic axes they possess.
The fundamental distinction between uniaxial and biaxial anisotropic minerals is based on their number of optic axes. Uniaxial minerals, found in the tetragonal and hexagonal systems, have only one optic axis along which light does not undergo double refraction. Biaxial minerals, found in the orthorhombic, monoclinic, and triclinic systems, have two such axes. Identifying the number of optic axes through interference figures is a primary method for determining a mineral's crystal system under a petrographic microscope.

230. (D) V. M. Goldschmidt
Victor Moritz Goldschmidt is often considered the founder of modern geochemistry. He proposed the fundamental classification of chemical elements into four groups—lithophile, siderophile, chalcophile, and atmophile—based on their preferred host phases (silicates, iron metal, sulfides, and gases). This system was derived from his studies of meteorites and the Earth's early differentiation. His work provided the scientific framework for understanding how elements are distributed throughout the various layers of the Earth and other planetary bodies in the solar system.

231. (A) A beta particle (electron)
The radioactive transformation of Rubidium-87 into Strontium-87 occurs via beta decay. In this process, a neutron within the rubidium nucleus spontaneously converts into a proton while emitting a high-energy electron, which is known as a beta particle. This transformation increases the atomic number by one but leaves the atomic mass unchanged at 87. This specific decay mechanism is the foundation of the Rb-Sr geochronological dating method, which is widely used to determine the age of ancient geological samples.

232. (C) The mantle
The Earth's mantle is a thick silicate layer that sits between the crust and the core. While it is composed primarily of silicate minerals like olivine and pyroxene, it is chemically distinct from the crust because it is much more enriched in magnesium and iron. This composition is described as ultramafic. The mantle represents about 84% of the Earth's total volume and its chemical and physical properties are crucial for understanding plate tectonics, mantle convection, and the planet's internal heat flow.

233. (A) the reaction is spontaneous under the given conditions.
In thermodynamics, Gibbs Free Energy (G) is a measure of the chemical potential of a system. For a geochemical reaction to occur spontaneously at constant temperature and pressure, the total Gibbs Free Energy of the products must be less than that of the reactants, resulting in a negative change in G. This principle allows geochemists to predict whether a mineral will be stable, dissolve, or react with other substances under specific conditions found in the Earth's crust or mantle.

234. (D) geochemical cycle.
A geochemical cycle describes the pathways and processes by which a chemical element moves between the Earth's major reservoirs, such as the atmosphere, oceans, biosphere, and solid rocks. The carbon cycle is a prime example, involving processes like volcanic outgassing, photosynthesis, weathering of silicate rocks, and the burial of organic matter. These cycles are fundamental for maintaining the planet's chemical balance and climate, illustrating the dynamic interaction between the geological and biological systems over vast timescales.

235. (B) Loss of the daughter isotope, gaseous Argon, from the rock can lead to an erroneously young age.
The K-Ar dating method is based on the decay of Potassium-40 to the noble gas Argon-40. Because argon is a gas that is not chemically bonded to the crystal lattice, it can easily escape if the rock is reheated during its history. If a rock loses argon, the measured ratio of argon to potassium will be too low, resulting in a calculated age that is younger than the rock's true age. This argon loss" is a major challenge in geochronology.

236. (C) Lithophile
Uranium (U) and Thorium (Th) are classified as lithophile elements in Goldschmidt's geochemical system. These elements have a strong affinity for oxygen and are readily incorporated into silicate and oxide minerals rather than metallic iron or

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191. (A) 2, 1, 3, 4
To perform the Becke line test, the mineral grain is first brought into sharp focus. Once focused, the bright Becke line can be seen at the grain's edge. When the microscope stage is then lowered, increasing the distance between the lens and the grain, the Becke line will appear to move. The final step is to observe if it moves into the grain or out into the surrounding oil, which reveals which material has the higher refractive index.

192. (B) distribution among the phases of meteorite systems (metal, sulfide, silicate).
V.M. Goldschmidt developed his geochemical classification by observing how elements distributed themselves when a meteorite system cooled and separated into metallic, sulfide, and silicate phases. This mimicked the early differentiation of planets. Based on these observations, he categorized elements as siderophile (iron-loving), chalcophile (sulfur-loving), or lithophile (rock-loving). This system remains a cornerstone of modern geochemistry, providing a framework for understanding the distribution of elements between the Earth's core, mantle, and crust.

193. (A) multiple sequential alpha and beta decay events.
The radioactive decay of Uranium-238 to Lead-206 is not a single step but a complex decay series. It involves a total of 14 separate decay events, including 8 alpha decays and 6 beta decays. Along the way, it passes through various intermediate radioactive isotopes of elements like thorium, radium, and radon. This long and predictable sequence is what makes the U-Pb system such a powerful and versatile clock for dating geological materials over billions of years.

194. (D) Statement I is false, but Statement II is true.
The Earth's core is primarily composed of siderophile (iron-loving) elements like iron and nickel, not lithophile elements. Lithophile elements, like oxygen, silicon, and aluminum, are concentrated in the silicate-rich crust and mantle. It is well-established that oxygen and silicon are the two most abundant elements in the Earth's crust. Therefore, the first statement is false, and the second statement is true, accurately reflecting the known chemical differentiation and overall composition of the Earth's major internal layers.

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195. (D) Second Law.
The Second Law of Thermodynamics states that for any spontaneous process in an isolated system, the total entropy always increases. Entropy is a measure of the disorder or randomness of a system. This law dictates the direction of natural processes, indicating that systems move toward states of greater equilibrium and disorder. In geochemistry, it explains why energy dissipates and why certain chemical reactions proceed in a specific direction toward a more stable, higher-entropy state over time.

196. (C) The total amount of an element on Earth is fixed, but it moves between different reservoirs.
The fundamental principle of the geochemical cycle is the conservation of matter. While the total mass of a non-radiogenic element on Earth remains constant, it is continuously moving between different parts of the Earth system, such as the crust, mantle, oceans, and atmosphere. These parts are called reservoirs. Processes like volcanism, weathering, and subduction act as pathways, transferring elements from one reservoir to another over various timescales, thus shaping the planet's chemical evolution and environment.

197. (B) U-Pb and Rb-Sr
Both the U-Pb and Rb-Sr dating systems involve radioactive parent isotopes with very long half-lives—billions of years. This makes them perfectly suited for dating the most ancient rocks and events in Earth's history, stretching back to the formation of the solar system. In contrast, systems like Carbon-14 or Tritium have very short half-lives and are only useful for dating relatively recent events in the late Quaternary. Sm-Nd is also useful for ancient rocks, but not when paired with Carbon-14.

198. (D) Lithophile.
Lithophile elements are those that have a strong chemical affinity for oxygen and are easily incorporated into silicate minerals. In Goldschmidt's classification, these rock-loving" elements are the primary constituents of the Earth's silicate crust and mantle. Examples include silicon, aluminum, magnesium,

and those that are anisotropic. Isotropic minerals, which belong to the isometric system, treat light the same way in all directions. Anisotropic minerals, belonging to all other systems, have optical properties that vary with direction. This fundamental distinction is the first step in identifying a mineral using a petrographic microscope and is a direct consequence of the mineral's internal crystal symmetry.

184. (C) double refraction.
Double refraction is the phenomenon that occurs when a light ray enters an anisotropic mineral and is split into two separate rays. These two rays travel at different speeds and are polarized in planes that are perpendicular to each other. This splitting is caused by the mineral's asymmetrical internal structure, which offers different resistance to light vibrations in different directions. This fundamental property is responsible for the interference colors and other optical effects seen in polarized light microscopy.

185. (A) Both A and R are true and R is the correct explanation of A.
In the isometric crystal system, the atoms are arranged in a highly symmetrical cubic lattice. Because of this uniform internal structure, the velocity of light is the same regardless of the direction in which it travels through the crystal. This means the mineral has only one refractive index and does not split light rays. Therefore, all isometric minerals are optically isotropic, and they remain dark when viewed under crossed polarizers on a petrographic microscope stage.

186. (D) The maximum difference in refractive indices within an anisotropic mineral.
Birefringence is the numerical difference between the maximum and minimum refractive indices of an anisotropic mineral. It is a measure of the degree to which a mineral can split and retard light rays. This property is constant for a given mineral species and is a key diagnostic feature. In thin section, higher birefringence results in higher-order interference colors, which can be identified using the Michel-Lévy chart, helping geologists to identify unknown mineral grains accurately.

187. (B) The immersion method using the Becke line
The immersion method is the most standard laboratory technique for determining the refractive index of a mineral grain. It involves placing the grain in a liquid of known refractive index and observing it under a microscope. By adjusting the focus and watching the movement of the Becke line—a bright line of light at the grain boundary—the geologist can determine if the mineral's index is higher or lower than the liquid's, effectively bracketing its value.

188. (A) P-3, Q-2, R-1, S-4
The optical character of a mineral is directly determined by its crystal system. Isometric minerals are isotropic. Tetragonal and hexagonal minerals are uniaxial because they have one optic axis. Orthorhombic, monoclinic, and triclinic minerals are biaxial because they have two optic axes. This matching correctly links these crystal systems to their corresponding optical classifications, which is the basic framework used for mineral identification using polarized light and petrographic microscopy in geological research.

189. (D) Interference colors.
Interference colors are a phenomenon exclusive to anisotropic minerals, which can split and retard light rays. Because isotropic minerals do not split light, there is no phase difference created between rays to produce interference. Consequently, when viewed between crossed polarizers, an isotropic mineral simply blocks all light and remains dark (extinct) regardless of how it is oriented or rotated on the microscope stage. The other listed observations, such as extinction and true color, are characteristic of isotropic minerals.

190. (A) refractive index.
Refraction is the change in direction of a light ray as it passes from one medium into another. This bending occurs because light travels at different speeds in different materials. The refractive index is the measure of this speed reduction. When light moves between two substances with different refractive indices, such as air and a mineral, its speed changes abruptly at the interface, causing its path to bend. This fundamental principle of optics is the basis for many mineral identification techniques.

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minerals typically contain larger cations that do not fit into the calcite lattice. They do share the same general formula, RCO_3, and aragonite is a well-known polymorph of calcium carbonate, but their internal structures are fundamentally different.

207. (B) an isomorphous series.
An isomorphous series, also known as a solid solution series, occurs when two or more minerals share the same crystal structure but have different chemical compositions. This is possible when ions of similar size and charge can substitute for one another in the same lattice sites. The most famous example is the plagioclase series, which varies continuously from sodium-rich albite to calcium-rich anorthite. This phenomenon is fundamental to understanding the chemical variability and crystallization of many important rock-forming minerals.

208. (B) X_2O_3 type oxides
Hematite, with the chemical formula Fe_2O_3, is a member of the X_2O_3 oxide group. This group is characterized by a ratio of two metal cations to three oxygen anions. Other common minerals in this class include corundum (Al_2O_3). Hematite is a very important iron ore mineral and is responsible for the red color found in many rocks and soils. Its structure consists of oxygen atoms in a hexagonal close-packed arrangement with iron cations filling two-thirds of the available octahedral sites.

209. (A) Al^{3+} for Si^{4+}
In the plagioclase feldspar series, a solid solution exists between albite ($NaAlSi_3O_8$) and anorthite ($CaAl_2Si_2O_8$). When a divalent calcium ion (Ca^{2+}) replaces a monovalent sodium ion (Na+), the crystal must gain an extra positive charge to remain electrically neutral. This is achieved by simultaneously replacing a tetravalent silicon ion (Si_{4+}) with a trivalent aluminum ion (Al_{3+}). This coupled substitution" maintains the overall charge balance of the framework silicate structure as its composition varies between the two end-members.

210. (C) Feldspars and Quartz
Tectosilicates, which include the feldspar group and the quartz group, are characterized by a three-dimensional framework where every silica tetrahedron shares all four of its oxygen atoms with neighboring tetrahedra. This complete sharing results in a silicon to oxygen ratio of 1:2, as seen in the formula for quartz (SiO_2). This rigid, interconnected structure makes these minerals very stable and is responsible for their abundance in the Earth's crust. Most feldspars follow this framework pattern with some aluminum substitution.

211. (D) A framework structure with large channels and cavities.
Zeolites are tectosilicates that possess a uniquely open three-dimensional framework built from silica and alumina tetrahedra. This framework is not densely packed but instead contains large, interconnected channels and cavities. These spaces can host water molecules and various cations that are only loosely held. Because the overall framework is strong, these molecules can move in and out or be replaced without the crystal structure collapsing, which allows zeolites to function as molecular sieves and ion exchangers.

212. (D) 1, 2 and 3
All three statements correctly describe the mica group. They are phyllosilicates, or sheet silicates, characterized by continuous two-dimensional layers of silica tetrahedra. This internal structure results in the group's most famous physical property: perfect basal cleavage. Biotite is a common member of this group and is specifically identified as being rich in iron and magnesium, which gives it its characteristic dark color. Together, these features define the mica group and its role as a major rock-forming mineral family.

213. (B) a chemical incompatibility due to silica saturation levels.
Nepheline is a feldspathoid, which means it is a mineral that only forms when there is not enough silica in the magma to produce the corresponding feldspar (albite). Because nepheline is chemically undersaturated with respect to silica, it would react with any available free silica (quartz) to form albite. Therefore, quartz and nepheline are chemically incompatible and cannot coexist in stable equilibrium within the same igneous rock. Their presence is mutually exclusive based on the silica content of the parent magma.

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calcium, and the alkali metals. During the early differentiation of the Earth, these elements were excluded from the metallic core and instead formed the silicate shell that makes up the bulk of our planet's outer layers.

199. (A) Strontium-87 (^{87}Sr)
Rubidium-87 is an unstable isotope that undergoes beta decay to become Strontium-87. In this process, a neutron in the rubidium nucleus emits an electron (a beta particle) and transforms into a proton. This increases the atomic number by one, changing the element from rubidium to strontium, while the atomic mass remains 87. This specific parent-daughter relationship is the basis for the Rb-Sr dating method, which is a key tool for determining the ages of old rocks.

200. (C) Siderophile
Siderophile elements, or iron-loving" elements, have a high affinity for metallic iron and readily form alloys with it. During the early, molten stage of Earth's history, these elements—including iron, nickel, cobalt, and precious metals like gold and platinum—were pulled toward the center of the planet as it differentiated. This process concentrated them in the Earth's core. Their relative scarcity in the silicate crust and mantle today is a direct result of their siderophile nature and this early planetary event.

201. (A) ^{40}Ar and ^{40}Ca.
Potassium-40 is a unique radioactive isotope because it can decay along two different pathways. Approximately 89% of Potassium-40 atoms undergo beta decay to become Calcium-40. The remaining 11% undergo electron capture or positron emission to become Argon-40. While the decay to Calcium-40 is more common, it is the decay to the noble gas Argon-40 that is most widely used by geologists for radiometric dating, as argon is easily measured and usually absent in newly formed volcanic rocks.

202. (D) Pyrite (FeS_2)
Pyrite is the classic example of an AX2 type sulfide mineral. Its chemical formula, FeS_2, indicates that there are two sulfur atoms for every one iron atom. In its crystal structure, the sulfur atoms occur as distinct disulfide pairs (S_2). This is different from the AX type, like galena (PbS) or sphalerite (ZnS), where there is a one-to-one ratio. Argentite is an A2X type. Pyrite's unique AX2 structure contributes to its characteristic cubic crystal habit and metallic luster.

203. (B) Polymorphism.
Diamond and graphite are both composed entirely of pure carbon, but they have radically different crystal structures. Diamond has a rigid, three-dimensional framework, making it the hardest natural substance. Graphite has a layered structure, making it very soft and useful as a lubricant. This phenomenon, where the same chemical substance exists in different structural forms, is called polymorphism. It occurs because the atoms arrange themselves differently based on the pressure and temperature conditions during the mineral's formation.

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204. (C) hydrous sulfate.
Gypsum is classified as a hydrous sulfate because its chemical formula, $CaSO_4 \cdot 2H_2O$, includes two molecules of water for every unit of calcium sulfate. This structural water is an integral part of the mineral's crystal lattice. Gypsum is one of the most common sulfate minerals and typically forms in evaporite deposits. If the water is removed, usually through heating or pressure, gypsum transforms into anhydrite, which is the anhydrous (water-free) equivalent of the same basic chemical compound.

205. (D) Inosilicate (double chain)
The amphibole group of minerals is classified as inosilicates because their structure is based on chains of silica tetrahedra. Specifically, amphiboles consist of double chains where two single chains are linked together by sharing oxygen atoms. This double-chain arrangement is the defining structural feature of the group, influencing their complex chemical formulas, their characteristic needle-like crystal habit, and their diagnostic cleavage angles of 56 and 124 degrees, which help geologists identify them in the field.

206. (A) They are isostructural with calcite.
The statement that aragonite group minerals are isostructural with calcite is incorrect. While both are carbonates, they belong to different crystal systems: the aragonite group is orthorhombic, while the calcite group is trigonal. This difference in symmetry arises because the aragonite group

specimens and thin sections. While other minerals like chlorite or olivine can be green, the specific shade of green associated with epidote is quite characteristic. It is a sorosilicate mineral that often forms as a product of the alteration of calcium-rich plagioclase feldspars.

222. (A) Phyllosilicate
Chlorite group minerals are classified as phyllosilicates, also known as sheet silicates. Their structure consists of alternating layers of silica tetrahedra and octahedra, which form continuous two-dimensional sheets. This arrangement is similar to that of micas and results in the mineral's characteristic platy habit and perfect basal cleavage. Chlorites are common in low-grade metamorphic rocks and are often identified by their green color, which reflects their high content of magnesium and iron within the silicate sheet structure.

223. (B) All varieties of corundum are considered precious stones.
Corundum is an exceptionally hard mineral (9 on the Mohs scale), and all of its gem-quality varieties are traditionally classified as precious stones. This includes the red variety, ruby, and all other colors, which are collectively known as sapphire (including blue sapphire). Because of their extreme durability, rarity, and beauty, these minerals have always been held in the highest regard alongside diamonds and emeralds. There is no category where gem-quality corundum is considered merely semi-precious" in traditional gemological classification systems.

224. (B) Garnet
Garnet crystallizes in the isometric (cubic) crystal system, which possesses the highest level of symmetry. Because of this uniform structure, light travels at the same speed in all directions through the crystal, making it optically isotropic. When viewed under a petrographic microscope with crossed polarizers, an isotropic mineral will remain dark even as the stage is rotated. Quartz, calcite, and hornblende belong to non-isometric systems and are therefore anisotropic, meaning they will show interference colors and light transmission.

225. (A) Both Statement I and Statement II are true.
Double refraction is an optical phenomenon in anisotropic minerals where light is split into two rays that travel at different velocities. This occurs because the mineral's internal structure is not symmetrical, causing light to interact differently with the lattice in different directions. Birefringence is the quantitative measure of this effect, calculated as the difference between the maximum and minimum refractive indices of the crystal. Both statements correctly define these fundamental concepts of optical mineralogy that are essential for identifying minerals.

226. (C) greater than 1.54.
In the Becke line test, the Becke line is a bright band of light that appears at the boundary between a mineral grain and the immersion medium. A fundamental rule of this test is that when the microscope stage is lowered (increasing the distance between the lens and the grain), the Becke line always moves toward the medium with the higher refractive index. Since the line moves into the mineral grain from the 1.54 oil, the mineral's refractive index must be higher.

227. (D) uniaxial minerals.
Uniaxial minerals, which belong to the tetragonal and hexagonal crystal systems, possess a single optic axis. When light enters these minerals in any direction other than parallel to the optic axis, it is split into two rays: the ordinary ray (O-ray) and the extraordinary ray (E-ray). This process of double refraction is a defining characteristic of uniaxial minerals. Isotropic minerals do not split light, and biaxial minerals split light into two rays that are both considered extraordinary in their behavior.

228. (C) Their behavior in response to passing light, which is determined by their internal crystal structure.
The optical classification of minerals is based on how light interacts with their internal atomic arrangement. This classifies minerals as isotropic if their structure is highly symmetrical (isometric system) and uniform, or anisotropic if their structure is less symmetrical. Anisotropic minerals are further divided into uniaxial and biaxial groups based on the number of directions (optic axes) along which light travels without

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214. (D) Pyroxene
Augite is a very common rock-forming mineral and is the principal member of the pyroxene group. It is a single-chain inosilicate that typically contains calcium, magnesium, and iron. It is most commonly found in mafic and ultramafic igneous rocks like basalt and gabbro. Geologists identify augite in thin section by its characteristic two directions of cleavage that intersect at approximately 90 degrees, a feature that distinguishes it from the double-chain amphiboles which have different cleavage angles.

215. (A) Both A and R are true and R is the correct explanation of A.
Amphiboles have more complex chemical formulas than pyroxenes because their double-chain silicate structure allows for a wider variety of cation sites and substitutions. Crucially, the double-chain arrangement also creates a specific site in the lattice that must be occupied by the hydroxyl (OH) radical, making amphiboles hydrous minerals. Pyroxenes, being single-chain silicates, lack this essential hydroxyl group and have fewer cation sites, resulting in a generally simpler chemical composition compared to the diverse amphibole group.

216. (C) Garnet
Garnets are classified as nesosilicates because their atomic structure consists of individual SiO4 tetrahedra that are isolated from one another. They are not linked by shared oxygen atoms but are instead held together by ionic bonds with divalent and trivalent cations. In contrast, quartz is a tectosilicate, muscovite is a phyllosilicate, and augite is an inosilicate. The nesosilicate structure is the defining feature of the garnet group, contributing to its lack of cleavage and its high hardness.

217. (A) fibrous or slender prismatic crystals.
Sillimanite is a high-temperature polymorph of Al2SiO5 that is commonly found in high-grade metamorphic rocks like gneisses. It typically develops a distinctive crystal habit consisting of very slender, needle-like, or fibrous crystals. This fibrous variety is often referred to as fibrolite." While its polymorphs, kyanite and andalusite, form bladed or square prismatic crystals respectively, the slender and often matted fibrous appearance of sillimanite is a key diagnostic feature for its identification in metamorphic rock specimens.

218. (B) P-3, Q-1, R-4, S-2
Forsterite is the magnesium end-member of the olivine group. Almandine is a very common iron-rich member of the garnet group. Zoisite is a member of the epidote group, often occurring in metamorphic rocks. Amethyst is the well-known purple variety of quartz. This matching links these specific minerals to their correct broader mineralogical groups, which is essential for understanding their chemical relationships, crystal structures, and typical geological occurrences in various rock types throughout the Earth's crust.

219. (B) isolated silica tetrahedra linked by cations.
The olivine group minerals are defined by their nesosilicate structure, where individual SiO4 tetrahedra are isolated from one another. This means that no oxygen atoms are shared between the silicon units. Instead, the tetrahedra are held together within the crystal lattice by ionic bonds through divalent metal cations, typically magnesium and iron. This structural arrangement is the fundamental characteristic of the olivine group and is responsible for many of its physical properties, including its lack of cleavage and high melting temperature.

220. (C) It commonly exhibits perfect rhombohedral cleavage.
The statement that quartz exhibits perfect rhombohedral cleavage is incorrect. In fact, quartz is famous for having no cleavage at all because the silicon-oxygen bonds in its three-dimensional framework are equally strong in all directions. When broken, it exhibits a characteristic conchoidal (shell-like) fracture. Perfect rhombohedral cleavage is a diagnostic feature of the calcite group minerals, not quartz. Quartz is otherwise well-known for its hardness of 7, its chemical stability, and its abundance in many common rocks.

221. (D) Epidote
Epidote is a common mineral in metamorphic rocks, especially those of the greenschist facies, and is instantly recognizable by its distinctive pistachio-green color. This unique hue is a very reliable diagnostic property in both hand

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sulfide phases. Because they are incompatible" elements due to their large ionic radii and high charges, they tend to be concentrated in the Earth's silicate crust during the process of partial melting and differentiation of the mantle over geologic time.

237. (D) Granitic (felsic)
The Earth's continental crust is primarily composed of felsic rocks, with granite being the most representative type. This crust is characterized by an abundance of silica, aluminum, potassium, and sodium, making it less dense than the oceanic crust or the mantle. This relatively low density allows the continental crust to float" higher on the mantle. The composition of the continental crust is the result of billions of years of complex geological processes, including partial melting and plate tectonics.

238. (A) an alpha particle.
The radioactive decay of Samarium-147 to Neodymium-143 is an alpha decay process. An alpha particle consists of two protons and two neutrons, essentially a helium nucleus. When the samarium nucleus emits this particle, its atomic number decreases by two and its atomic mass decreases by four. This specific decay scheme is extremely useful in geochemistry for dating very old rocks and for studying the long-term chemical evolution of the Earth's mantle and the formation of the continental crust.

239. (B) energy.
The First Law of Thermodynamics is the principle of the conservation of energy. It states that energy cannot be created or destroyed, only transformed from one form to another, such as potential energy, kinetic energy, or heat. In the context of geochemistry, this law is used to account for all energy inputs and outputs during processes like magma crystallization, mineral reactions, and heat flow within the Earth. It provides the essential accounting framework for understanding the energy dynamics of geological systems.

240. (B) A2X type
Argentite is a silver sulfide mineral with the chemical formula Ag_2S. In the classification of sulfide minerals, this corresponds to the A_2X type, where A" represents the metal cation and X" represents the sulfur anion. This ratio of two silver atoms for every one sulfur atom is the defining stoichiometric feature of the mineral. Argentite is the high-temperature form of silver sulfide, while acanthite is the stable form at lower temperatures, though both share the same A2X chemistry.

241. (A) way in which silica tetrahedra are linked together.
Silicate minerals are classified into groups—such as nesosilicates, inosilicates, and tectosilicates—based on the degree of polymerization of the silica tetrahedra. This refers to how many oxygen atoms are shared between adjacent tetrahedra. This fundamental structural arrangement determines the mineral's Si:O ratio, its chemical formula, and its physical properties like cleavage and habit. This classification system is the primary way geologists organize the most common and important minerals that make up the Earth's crust and mantle.

242. (D) 1, 2 and 3
All three statements correctly define fundamental mineralogical concepts. Isomorphism involves minerals with different chemistry sharing the same structure. Polymorphism is when one chemical compound can take multiple structural forms. Exsolution is the separation of a solid solution during cooling. These three phenomena explain much of the chemical and structural diversity found in natural minerals and are essential for geologists to understand the conditions under which different rocks and minerals formed and evolved throughout the Earth's history.

243. (D) XY_2O_4
There is an error in the provided answer text; Corundum (Al_2O_3) and Hematite (Fe_2O_3) are actually examples of the X_2O_3 oxide type, while the XY_2O_4 type represents the spinel group. However, following the task instructions to use the exact provided text, they are associated here with the XY_2O_4 label. In standard mineralogy, X_2O_3 minerals feature a two-to-three cation-to-oxygen ratio, and corundum and hematite are the most prominent members of this class, known for their high hardness and importance in geology.

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different wavelengths of light are reflected, creating the beautiful, shifting spectrum of colors that is characteristic of high-quality opal.

259. (D) Chlorite
Chlorite is a phyllosilicate (sheet silicate) that is a very common indicator of low-grade metamorphism, particularly in the greenschist facies. It is characterized by its green color and its tendency to form small, plate-like crystals with perfect basal cleavage. It often forms through the alteration of other ferromagnesian minerals like biotite, pyroxene, or amphibole. While minerals like sillimanite, garnet, and staurolite are indicators of medium-to-high-grade metamorphism, chlorite is the classic mineral used to identify the lowest stages of metamorphic change.

260. (C) show double refraction.
The fundamental difference between isotropic and anisotropic minerals is how they interact with light. Anisotropic minerals, which belong to any crystal system other than isometric, possess an internal structure that is not uniform in all directions. This causes them to split incoming light into two rays that travel at different speeds, a phenomenon called double refraction. Isotropic minerals do not split light. This difference is easily seen under a polarizing microscope, where anisotropic minerals display interference colors while isotropic minerals remain dark when viewed between crossed polars.

261. (B) n(mineral) < n(oil).
In the Becke line test, the Becke line is a bright band of light that appears at the contact between a mineral and the immersion oil. The rule of this test states that when the microscope stage is lowered (increasing the focal distance), the Becke line always moves into the material that has the higher refractive index. If the line moves out of the mineral and into the surrounding oil, it means the oil has the higher refractive index, and thus n(mineral) is less than n(oil).

262. (D) birefringence.
The interference color of a mineral in thin section is determined by the retardation of light as it passes through the crystal. Retardation is the product of the mineral's thickness and its birefringence (the difference between its maximum and minimum refractive indices). Since geological thin sections are ground to a standard thickness, the maximum interference color depends entirely on the mineral's intrinsic birefringence. Geologists use these colors and the Michel-Lévy chart as a primary tool to identify unknown minerals by estimating their birefringence.

263. (A) biaxial.
In optical mineralogy, minerals are classified based on the number of optic axes they possess. Minerals in the orthorhombic, monoclinic, and triclinic systems have the lowest levels of symmetry, which results in them having two distinct optic axes. Therefore, they are all classified as biaxial. This distinguishes them from isotropic minerals (zero optic axes) and uniaxial minerals (one optic axis). Determining if a mineral is biaxial is a critical step in its identification using the interference figures seen under a petrographic microscope.

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264. (C) Refraction
Refraction is the fundamental principle of optics that describes why light bends when it moves from one medium into another. This happens because light travels at different speeds in different materials, such as air, water, glass, or minerals. The degree of bending is determined by the refractive index of the materials. In petrography, refraction is the phenomenon that causes minerals to stand out from their mounting medium (relief) and is the basis for the Becke line test used to identify unknown minerals.

265. (A) Chalcophile.
Although lead (Pb) can occasionally behave like a lithophile element by substituting for potassium in some silicate minerals, its primary geochemical affinity is for sulfur. In Goldschmidt's classification, lead is strongly categorized as a chalcophile element. It is most commonly found in nature as the sulfide mineral galena (PbS). During the Earth's differentiation and in the formation of ore deposits, lead tends to be concentrated in the sulfide phase, which is the defining characteristic of all elements in the chalcophile group.

with the melt to form pyroxene, followed by amphibole, and then biotite mica. Finally, at the lowest temperatures, quartz crystallizes from the remaining silica-rich melt. This sequence (olivine, pyroxene, amphibole, quartz) explains the typical mineral assemblages found in different types of igneous rocks.

252. (C) Andalusite
Andalusite is the Al_2SiO_5 polymorph that is stable at relatively low pressures and moderate-to-high temperatures. These conditions are characteristic of contact metamorphism, where rocks are heated by a nearby magma intrusion at shallow crustal depths. Under these circumstances, andalusite is the preferred crystal form over kyanite (high pressure) or sillimanite (high temperature). It is often found in metamorphic aureoles and is frequently identified by the presence of carbonaceous inclusions that form a cross-shaped pattern known as chiastolite.

253. (D) Fayalite.
Fayalite is the iron-rich end-member of the olivine solid solution series, with the chemical formula Fe_2SiO_4. It represents the case where iron is the dominant divalent cation in the nesosilicate structure. While magnesium-rich olivine (forsterite) is common in the mantle and mafic rocks, fayalite is less common but can be found in some iron-rich igneous rocks and certain metamorphic environments. It is typically darker in color and has a higher specific gravity than its magnesium-rich counterpart, forsterite.

254. (A) The Si-O bonds are equally strong in all directions within its framework structure.
Quartz is a tectosilicate where every silica tetrahedron shares all four of its oxygen atoms with its neighbors. The silicon-oxygen bonds are exceptionally strong and are distributed uniformly throughout the entire three-dimensional lattice. Because there are no planes of relative weakness within the structure, the mineral does not have cleavage. Instead, it breaks along smooth, curved surfaces, which is known as conchoidal fracture. This property is a direct result of the high degree of polymerization and uniform bond strength in quartz.

255. (B) Epidote
Pistachio green is the most characteristic and diagnostic color of the mineral epidote. This unique hue makes it relatively easy to identify in both hand specimens and thin sections under a microscope. Epidote is a common product of the hydrothermal alteration or low-grade metamorphism of calcium-rich minerals like plagioclase feldspar. While minerals like olivine or chlorite are also green, they have different shades and structural features. The specific pistachio-green color remains the classic field identification mark for the epidote mineral group.

256. (B) They are nesosilicates, often forming equant (dodecahedral or trapezohedral) crystals.
Garnets are classified as nesosilicates, characterized by isolated silica tetrahedra. A key feature of the garnet group is their high level of symmetry within the isometric system, which frequently leads to the formation of well-developed, equant crystals such as dodecahedrons or trapezohedrons. They also lack cleavage and are known for their high hardness and high relief under the microscope. These properties, combined with their typical red-to-brown colors, make garnets one of the most recognizable minerals in metamorphic and igneous rocks.

257. (A) Corundum (Al_2O_3)
Ruby and sapphire are the two most famous and valuable varieties of the mineral corundum, which is composed of aluminum oxide (Al_2O_3). Corundum is exceptionally durable, having a hardness of 9 on the Mohs scale. Pure corundum is colorless; the vibrant red color of ruby is caused by trace amounts of chromium, while the blue of sapphire is caused by iron and titanium. Both are considered precious gemstones due to their beauty, extreme hardness, and rarity, making them highly desirable for high-quality jewelry.

258. (C) diffraction of light from a regular packing of microscopic silica spheres.
The vibrant play-of-color" seen in precious opal is not caused by pigmentation but is a physical optical effect. Opal is composed of billions of sub-microscopic silica spheres that are arranged in a regular, three-dimensional grid. As light passes through this structure, it is diffracted by the gaps between the spheres. Depending on the size of the spheres and the angle of observation,

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CHAPTER 04

Igneous and Metamorphic Petrology

1. Which of the following best defines the term 'magma'?
(A) Solid crystalline rock found deep within the Earth's crust.
(B) A mixture of molten rock, suspended crystals, and dissolved gases.
(C) Sedimentary deposits that have been lithified under high pressure.
(D) Metamorphic rock that has undergone partial melting processes.

2. Which statement correctly identifies a primary factor affecting the composition of magma?
(A) The degree of partial melting of the source rock.
(B) The rate of surface erosion above the magma chamber.
(C) The magnetic polarity of the Earth at the time of eruption.
(D) The atmospheric pressure at the Earth's surface.

3. Given below are two statements regarding magma evolution.
Statement I : Magmatic differentiation describes processes that cause magma composition to change.
Statement II : Fractional crystallization is a key mechanism of magmatic differentiation.
Which of the above statements is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

4. The process by which magma changes composition by incorporating and melting surrounding country rock is known as:
(A) Fractional crystallization
(B) Metasomatism
(C) Anatexis
(D) Assimilation

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5. Which of the following is NOT a process associated with magmatic differentiation?
(A) Crystal settling
(B) Liquid immiscibility
(C) Diagenesis
(D) Filter pressing

6. In a monary silica system, what does the liquidus line represent?
(A) The temperature at which the first solid crystal begins to melt.
(B) The boundary separating the all-liquid field from the field of liquid and crystals.
(C) The temperature below which the entire system is considered solid.
(D) The pressure at which silica polymorphs transform into one another.

7. Match the Phase Equilibria Concepts in List I with their Descriptions in List II.
List I: (Phase Equilibria Concept)
P. Eutectic point
Q. Peritectic point
R. Liquidus
S. Solidus
List II: (Description)
1. Temperature at which a solid begins to melt.
2. An incongruent melting point where a solid phase reacts with the liquid to produce a new solid phase.
3. Temperature above which a material is completely liquid.
4. The lowest possible melting temperature over the mixing ratio for all components.
(A) P-4, Q-2, R-3, S-1
(B) P-1, Q-3, R-2, S-4
(C) P-4, Q-1, R-3, S-2
(D) P-2, Q-4, R-1, S-3

8. The following question consists of two statements, an Assertion (A) and a Reason (R). Select the correct answer using the codes given below.

266. (D) U-Pb
A concordia diagram is a specialized graphical tool used in U-Pb geochronology to determine the age of minerals like zircon. It plots the ratios of the two independent uranium-lead decay series (U-238 to Pb-206 and U-235 to Pb-207) against each other. If the system has remained closed, the data points will fall on a curve called the concordia." This method is incredibly powerful because it can both determine the age of a rock and detect if the rock has lost lead during its history.

267. (B) Second Law of Thermodynamics.
The Second Law of Thermodynamics states that the total entropy, or disorder, of an isolated system will always increase over time as it moves toward equilibrium. This fundamental law explains the direction of natural processes, indicating that systems naturally progress from more organized states to more disordered ones. In geochemistry, this principle is used to understand energy dissipation, the direction of spontaneous chemical reactions, and the ultimate distribution of elements and energy throughout the Earth's crust, mantle, and atmosphere.

268. (C) geochemical cycle.
A geochemical cycle describes the continuous path that an element, like phosphorus or carbon, follows as it moves through the Earth's various reservoirs, including rocks, soil, water, and living organisms. The phosphorus cycle is particularly important because phosphorus is a vital nutrient that is released from rocks through weathering, taken up by plants, and eventually transported to the oceans where it can be buried and recycled into new geological formations over millions of years. This illustrates the dynamic nature of Earth's chemistry.

269. (D) Lithophile elements like Si, Al, K, and Na.
During the early differentiation of the Earth, lithophile elements—those with a strong affinity for oxygen—were concentrated in the outermost layers because they are relatively light and prefer to form silicate minerals. As a result, the Earth's crust is significantly enriched in silicon (Si), aluminum (Al), potassium (K), and sodium (Na) compared to the Earth as a whole. In contrast, the bulk Earth composition is dominated by iron and nickel, which are mostly sequestered in the core due to their higher density and siderophile nature.

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270. (A) $^{87}Rb/^{86}Sr$ vs. $^{87}Sr/^{86}Sr$.
An isochron diagram is a fundamental tool in Rb-Sr geochronology used to determine the age of a suite of related rocks or minerals. It involves plotting the ratio of the radiogenic daughter (Sr-87) to a stable reference isotope (Sr-86) on the y-axis, and the ratio of the radioactive parent (Rb-87) to the same reference isotope on the x-axis. If the samples are the same age and from the same source, they will form a straight line (isochron), whose slope is used to calculate the time elapsed since the samples formed.

271. (B) Atmophile
Atmophile elements are those that are volatile and have a strong affinity for the gaseous state. In Goldschmidt's classification, this group includes the noble gases (like helium, neon, and argon) as well as nitrogen and hydrogen. These elements are primarily concentrated in the Earth's atmosphere and hydrosphere. During the planet's formation and differentiation, these elements were largely excluded from the solid silicate and metallic phases, either remaining in the surrounding gas envelope or being outgassed from the interior later through volcanic activity.

272. (D) 1, 2 and 3
All three statements correctly describe the fundamental rules of radioactive decay. Alpha decay involves the loss of a helium nucleus, reducing mass and atomic number. Beta decay involves a neutron turning into a proton and an electron, increasing the atomic number while keeping mass constant. Electron capture involves a proton capturing an electron to become a neutron, decreasing the atomic number with constant mass. These precise changes in atomic structure are the basis for all radiometric dating methods used to determine the vast ages of geological materials.

273. (A) Siderophile
Siderophile, or iron-loving," elements have a high chemical affinity for metallic iron. During the early differentiation of the Earth, when the planet was largely molten, these elements—including iron, nickel, cobalt, and gold—concentrated together and sank toward the center due to their

high density. This process created the Earth's metallic core. The high abundance of iron and nickel in the core, and their relative scarcity in the crust, is the primary evidence for this early planetary-scale separation based on the chemical affinities defined in the Goldschmidt classification.

274. (C) Polymorph.
A polymorph is a mineral that has the same chemical composition as another mineral but a different crystal structure. This occurs when a chemical compound crystallizes under different pressure and temperature conditions. Famous examples include diamond and graphite (both carbon) or calcite and aragonite (both calcium carbonate). While their chemistry is identical, their physical properties like hardness, density, and cleavage are usually very different because of the way their atoms are arranged in space. This is a fundamental concept in mineralogy and petrology.

275. (A) Both A and R are true and R is the correct explanation of A.
Zeolites are technologically and industrially important because of their unique open tectosilicate framework. This structure contains a network of large channels and cavities that can host exchangeable ions and water molecules. This allows them to act as molecular sieves, selectively trapping certain ions while letting others through, which is the basis for their use as water softeners and industrial catalysts. Both the statement and its reason accurately describe why zeolites possess these valuable properties, illustrating the direct link between a mineral's atomic structure and its practical applications.

276. (C) Hornblende
Hornblende is a common rock-forming mineral that belongs to the amphibole group, which is characterized by a double-chain inosilicate structure. In this structure, two single chains of silica tetrahedra are linked together by sharing oxygen atoms. Diopside is a single-chain silicate (pyroxene), olivine is an isolated tetrahedron silicate (nesosilicate), and muscovite is a sheet silicate (phyllosilicate). The double-chain structure of hornblende results in its characteristic needle-like crystal habit and its diagnostic cleavage angles of approximately 56 and 124 degrees.

277. (B) SiO_2
Quartz is one of the most common and recognizable minerals on Earth, and its chemical formula is simply SiO_2, consisting of one silicon atom for every two oxygen atoms. It is a framework silicate where every oxygen is shared between two silica tetrahedra, creating a very stable and durable structure. While other minerals like orthoclase or kyanite contain silicon and oxygen, they also include other elements like aluminum and potassium. Quartz, in its pure form, is composed entirely of silicon and oxygen, reflecting its simple but robust chemical makeup.

278. (B) P-4, Q-1, R-3, S-2
This matching correctly identifies the defining features of four major minerals. Calcite is a rhombohedral carbonate famous for its perfect cleavage. Gypsum is a hydrous sulfate that contains molecular water in its structure. Pyrite is an AX_2 type sulfide, known as fool's gold. Magnetite is an XY_2O_4 type oxide and is a member of the spinel group. These classifications are fundamental to systematic mineralogy, grouping minerals based on their chemical composition, structural type, and the resulting physical properties used for identification in the field.

279. (A) Pressure and Temperature.
Kyanite, andalusite, and sillimanite are polymorphs of Al_2SiO_5, meaning they share the same chemistry but differ in structure. The stability of each polymorph is primarily controlled by the pressure and temperature conditions during metamorphism. Kyanite is the high-pressure form, sillimanite is the high-temperature form, and andalusite is the form stable at low pressures. By identifying which of these minerals is present in a metamorphic rock, geologists can accurately reconstruct the physical conditions that the rock experienced deep within the Earth's crust during mountain-building events.

280. (C) The contrast in refractive index between a mineral and its mounting medium.
Relief is an optical effect seen under a microscope that describes how clearly a mineral grain stands out from the material surrounding it. This effect

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is caused by the difference between the refractive index of the mineral and the refractive index of the mounting medium (like Canada balsam or oil). If the indices are very different, the mineral will have thick, dark borders and appear to stand out" (high relief). If they are similar, the grain will be faint and hard to see (low relief).

281. (A) Chondritic meteorites.
Chondritic meteorites, particularly carbonaceous chondrites, are believed to represent the primitive, undifferentiated material from which the solar system and the Earth formed. Their chemical composition closely matches the Sun's photosphere for most non-volatile elements. Therefore, geochemists use the composition of these meteorites as the best model for the bulk Earth" composition. This allows them to calculate how elements have been redistributed between the Earth's core, mantle, and crust during the planet's history, providing a baseline for understanding planetary-scale chemical evolution.

282. (D) radioactive decay series.
The decay of Uranium-235 to Lead-207 is a complex radioactive process that involves a long sequence of intermediate steps. It is not a single transformation but a decay series" that includes multiple alpha and beta decay events. This series passes through various radioactive isotopes of elements like thorium, actinium, and protactinium before finally reaching a stable isotope of lead. This predictable and long-lasting series is one of the two U-Pb clocks used by geologists to determine the precise ages of ancient minerals and geological events.

283. (B) Olivine
The olivine group minerals are classified as nesosilicates because their crystal structure is built from isolated SiO_4 tetrahedra. In this arrangement, no oxygen atoms are shared between adjacent tetrahedra; instead, they are linked together by ionic bonds through divalent metal cations like magnesium and iron. Pyroxenes are chain silicates, micas are sheet silicates, and feldspars are framework silicates. The isolated tetrahedron structure is the fundamental characteristic of olivine, determining its lack of cleavage, high hardness, and its occurrence in mafic and ultramafic rocks.

284. (C) Muscovite
Muscovite is a member of the mica group, which is characterized by its sheet silicate (phyllosilicate) structure. In this structure, atoms are strongly bonded within two-dimensional layers, but the layers are only weakly held together by interlayer cations. This results in the mineral's most famous property: perfect basal cleavage in one direction. This allows muscovite to be easily split into extremely thin, flexible, and elastic sheets. This distinctive feature easily separates muscovite from other common minerals like quartz, calcite, or feldspar, which have different structures.

285. (D) The $(SiO_4\}$ tetrahedron
The fundamental building block of all silicate minerals is the silica tetrahedron, which consists of a single silicon cation surrounded by four oxygen anions in a tetrahedral arrangement. This unit can exist independently or link together in various ways by sharing oxygen atoms at the corners. The different ways these tetrahedra are connected—whether in isolated units, chains, sheets, or a three-dimensional framework—define the various classes of silicate minerals and determine their chemical formulas and physical properties, making it the most important unit in mineralogy.

286. (A) Staurolite
Staurolite is a complex iron-aluminum silicate mineral that often occurs in metamorphic rocks, but it is not a polymorph of Al_2SiO_5. Kyanite, andalusite, and sillimanite are the three classic polymorphs that share the exact same Al_2SiO_5 chemical formula but have different crystal structures. Staurolite has a different chemical composition and a different crystal structure entirely. While it often forms in the same metamorphic environments as the Al_2SiO_5 polymorphs, it is not part of that specific polymorphic group, which is used specifically for geothermobarometry by geologists.

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287. (B) Feldspar group
The feldspar group is by far the most abundant mineral group in the Earth's crust, making up approximately 60% of its total volume. Feldspars are framework silicates that occur in nearly all types of igneous, metamorphic, and sedimentary rocks. They are classified into two main series: the alkali feldspars (rich in potassium and sodium)

and the plagioclase feldspars (a solid solution between sodium and calcium). Their ubiquity and importance in rock formation make them the most fundamental minerals for geologists to study and identify in the field.

288. (A) Parent: ^{40}K, Daughter: ^{40}Ar
In the K-Ar (potassium-argon) dating method, the parent isotope is the radioactive form of potassium, Potassium-40. Over geologic time, a small percentage of these atoms decay into the stable daughter isotope, Argon-40, which is a noble gas. By measuring the ratio of the trapped Argon-40 to the remaining Potassium-40 in a mineral like biotite or hornblende, geologists can calculate how much time has passed since the mineral cooled below its closure temperature. This is one of the most widely used methods for dating volcanic rocks.

289. (A) Sulfur.
In Goldschmidt's geochemical classification, chalcophile" elements are those that have a strong affinity for sulfur. These elements tend to form sulfide minerals rather than silicate or oxide minerals. Common examples include copper, zinc, lead, and silver. During the chemical differentiation of the Earth and in the formation of ore deposits, these elements are concentrated in the sulfide phase. This classification is essential for understanding the distribution of metallic resources and the behavior of different elements during magmatic and hydrothermal processes throughout the Earth's history.

290. (C) Birefringence
Birefringence is an optical property exclusive to anisotropic minerals. It occurs because the internal structure of these minerals is not uniform, causing them to split a single incoming light ray into two separate rays that travel at different speeds. The numerical difference between the refractive indices of these two rays is the birefringence. Isotropic minerals, belonging to the highly symmetrical isometric system, do not split light and therefore have zero birefringence. This phenomenon is why anisotropic minerals display colorful interference effects under a polarizing microscope while isotropic minerals remain dark.

291. (D) Plagioclase feldspars.
The plagioclase feldspar group is defined by a continuous solid solution series between two end-members: albite, which is sodium-rich ($NaAlSi_3O_8$), and anorthite, which is calcium-rich ($CaAl_2Si_2O_8$). These minerals share the same basic framework structure but vary in their proportions of sodium and calcium. This series is traditionally divided into six minerals (albite, oligoclase, andesine, labradorite, bytownite, and anorthite) based on the percentage of anorthite. Plagioclase feldspars are ubiquitous in the Earth's crust and are a primary way geologists classify igneous rocks.

292. (C) First Law.
The First Law of Thermodynamics is the law of conservation of energy. It provides a mathematical relationship stating that the change in the internal energy of a system is equal to the heat added to the system minus the work done by the system on its surroundings. In geochemistry, this fundamental principle is used to account for all energy transfers during processes like mineral crystallization, tectonic movements, and chemical reactions. It ensures that energy is never created or destroyed, only transformed, providing the basic framework for all energy-related calculations in the earth sciences.

293. (B) Tectosilicate
Quartz is a classic example of a tectosilicate, also known as a framework silicate. Its atomic structure consists of a three-dimensional network of silica tetrahedra, where every single oxygen atom is shared between two adjacent tetrahedra. This complete sharing results in a very stable, rigid structure and the simple chemical formula SiO_2. Because every oxygen is part of the framework, there are no separate cation sites like those found in other silicate classes. This interconnected structure is responsible for quartz's high hardness, lack of cleavage, and exceptional chemical durability.

294. (D) Diamond
Diamond is a precious stone, traditionally considered one of the most valuable and highly prized gemstones in the world. It is composed of pure carbon and is the hardest natural substance known, measuring 10 on the Mohs scale. While agate, turquoise, and lapis lazuli are all beautiful

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and widely used in jewelry, they are classified as semi-precious stones because they are generally more abundant and less durable than diamond. The designation precious" is reserved for stones that possess exceptional beauty, extreme hardness, and significant rarity in nature.

295. (A) Iron and Magnesium.
Chlorite is a common green mineral in metamorphic and altered igneous rocks, and its distinctive color is primarily due to the presence of iron and magnesium in its crystal structure. It is a phyllosilicate (sheet silicate) that incorporates these ferromagnesian elements into its octahedral layers. The specific shade and intensity of the green can vary depending on the relative proportions of iron and magnesium. These elements are essential components of the chlorite chemical formula and are the reason it is often associated with the low-grade metamorphic alteration of other dark, ferromagnesian minerals.

296. (C) Uniaxial.
In optical mineralogy, a uniaxial mineral is one that has a single optic axis, which is a direction along which light travels without undergoing double refraction. This property is characteristic of minerals that crystallize in the tetragonal and hexagonal systems. In these minerals, the optic axis is parallel to the c-axis of the crystal. This distinguishes them from isotropic minerals, which have no optic axes, and biaxial minerals, which have two. Identifying a mineral as uniaxial is a primary step in its identification using a polarizing microscope.

297. (A) constant and not affected by physical or chemical conditions.
Radioactive decay is a nuclear process that occurs at a highly predictable and constant rate for each specific isotope. This rate is expressed as the half-life. A fundamental principle of geochronology is that this decay rate is an intrinsic property of the atomic nucleus and is not influenced by external factors like temperature, pressure, or the chemical environment. Because the decay rate remains constant over billions of years, it provides a reliable and absolute clock" that geologists use to measure the vast timescales of Earth's history and the ages of planetary materials.

298. (D) a specific component of the Earth system where an element resides.
In the context of a geochemical cycle, a reservoir is a specific part of the Earth system—such as the atmosphere, the oceans, the crust, or the biosphere—where a particular element or chemical species is stored for a period of time. Elements move between these reservoirs through various pathways and processes like weathering, sedimentation, or volcanic activity. Understanding the size of these reservoirs and the speed at which elements move between them (flux) is essential for grasping the overall chemical balance and evolution of the Earth's surface and interior environments.

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299. (B) Ultramafic.
The Earth's mantle is primarily composed of peridotite, which consists mainly of the silicate minerals olivine and pyroxene. This composition is termed ultramafic because it is extremely rich in magnesium and iron while being relatively low in silica. This layer represents the largest portion of the planet's volume and contrasts sharply with the more felsic continental crust.

300. (B) Zircon
Zircon ($ZrSiO_4$) is widely used in U–Pb radiometric dating because its crystal structure readily incorporates uranium atoms during crystallization but strongly excludes lead. This means any lead found later in zircon is produced by the radioactive decay of uranium, making age calculations reliable. Zircon is also highly resistant to weathering, heat, and metamorphism, so it preserves geological ages very accurately over billions of years.

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244. (C) double carbonate belonging to its own group.
Dolomite, $CaMg(CO_3)_2$, is a double carbonate mineral where calcium and magnesium ions are arranged in an ordered, alternating layer structure. Because of this specific internal ordering, it has a lower symmetry than the simple carbonates of the calcite group. Therefore, dolomite is placed in its own distinct mineral group. It is a major component of the sedimentary rock also called dolomite (or dolostone) and forms through the chemical alteration of limestone in a process known as dolomitization.

245. (A) Both A and R are true and R is the correct explanation of A.
Pyroxenes and amphiboles are both inosilicates but differ in their chain structure. Pyroxenes have single chains, leading to cleavage planes that intersect at approximately 90 degrees. Amphiboles have double chains, which are wider and result in a different internal geometry where cleavage planes intersect at roughly 124° and 56°. This difference in cleavage angles is the most reliable way to distinguish between these two major mineral groups in both hand specimen and under the microscope in rock sections.

246. (D) feldspathoid.
Nepheline is a primary member of the feldspathoid group. It is an aluminosilicate mineral that is chemically deficient in silica compared to the feldspar albite. Nepheline typically occurs in alkali-rich, silica-undersaturated igneous rocks like nepheline syenite. Because it is undersaturated, it can never coexist in equilibrium with quartz. Its presence is a definitive indicator that the magma from which it crystallized lacked enough silica to produce more common framework minerals like feldspar or to allow quartz to precipitate.

247. (A) Perfect basal cleavage
The mica group minerals are phyllosilicates, characterized by a structure of continuous two-dimensional sheets of silica tetrahedra. The chemical bonds within these sheets are very strong, but the bonds between the sheets, which are held together by large cations like potassium, are relatively weak. This structural arrangement results in the mica group's most famous physical property: perfect basal cleavage. This allows the mineral to be easily split into extremely thin, flexible, and elastic sheets, which is a key identifying feature.

248. (A) P-3, Q-1, R-4, S-2
This matching correctly links silicate structural classes with their representative mineral groups. Nesosilicates (isolated tetrahedra) include olivine. Inosilicates (single chains) are represented by the pyroxene group. Phyllosilicates (sheet silicates) include the mica group. Tectosilicates (framework silicates) include the large and abundant feldspar group. These classifications are based on how the silica tetrahedra share oxygen atoms, which is the fundamental basis for the systematic study and identification of all silicate minerals in the Earth's crust.

249. (A) Orthoclase
Orthoclase is a common member of the alkali feldspar group, which consists of framework silicates rich in potassium and sodium. Its chemical formula is $KAlSi_3O_8$. Alkali feldspars are major constituents of felsic igneous rocks like granite. In contrast, anorthite, bytownite, and labradorite are all members of the plagioclase feldspar series, which is a solid solution between sodium and calcium end-members. Orthoclase is identified by its lack of the characteristic striations often seen in plagioclase and its common pinkish-to-white color.

250. (D) open framework featuring channels of a fixed size.
The ability of zeolites to function as molecular sieves is due to their uniquely open tectosilicate framework. This structure contains a network of channels and cavities with precisely defined diameters. Molecules smaller than these channel openings can enter and be trapped or exchanged, while larger molecules are excluded. This property, combined with their ability to host exchangeable cations and water, makes zeolites invaluable in industrial processes like water purification, gas separation, and as catalysts in the petrochemical industry.

251. (B) 4, 3, 2, 1
Bowen's Reaction Series describes the sequence in which minerals crystallize from a cooling mafic magma. In the discontinuous series, the first mineral to form at high temperatures is olivine. As the temperature drops, olivine reacts

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Assertion (A) : In a binary eutectic system like Diopside-Anorthite, crystallization begins with a single mineral phase until the liquid composition reaches the eutectic point.
Reason (R) : At the eutectic point, both mineral phases crystallize simultaneously at a constant temperature.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

9. In the ternary system Albite-Anorthite-Diopside, what does a cotectic line represent?
(A) A line representing a path of constant temperature.
(B) A path followed during the process of fractional crystallization.
(C) A line along which two solid phases crystallize from the melt.
(D) The boundary between plagioclase and pyroxene solid solution.

10. The Fo-Fa-Silica system is particularly important for understanding the crystallization of which type of magma?
(A) Basaltic magmas
(B) Granitic magmas
(C) Andesitic magmas
(D) Carbonatite magmas

11. What is the basis for the IUGS classification of plutonic igneous rocks?
(A) The specific grain size and interlocking textures of the rock.
(B) The total percentage of mafic minerals within the rock matrix.
(C) The geological setting and depth where the rock is primarily found.
(D) The relative proportions of Quartz, Alkali feldspar, Plagioclase, and Feldspathoids.

12. Consider the following statements about the IUGS classification:
Statement I : It is primarily a mineralogical classification.
Statement II : It applies only to volcanic rocks.
Statement III: Rocks with more than 90% mafic minerals are classified using separate diagrams.
Which of the statements given above are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II and III

13. What is the 'Reaction Principle' in igneous petrology primarily concerned with?
(A) The reaction of magma with surrounding country rock.
(B) The chemical reactions leading to surface weathering.
(C) The sequential crystallization of minerals from cooling magma.
(D) The reaction between different magma bodies in a chamber.

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14. According to Bowen's Reaction Series, which mineral is most likely to crystallize first from a typical basaltic magma?
(A) Quartz
(B) Muscovite
(C) K-feldspar
(D) Olivine

15. The discontinuous series of Bowen's Reaction Series describes the formation of:
(A) Ferromagnesian silicates from olivine to biotite.
(B) Different compositions of plagioclase feldspar.
(C) Feldspathoids and their relationship to silica.
(D) Quartz, muscovite, and K-feldspar at low temperatures.

16. Which of the following pairs of igneous rock textures is incorrectly matched with its description?
(A) Phaneritic - Crystals are visible to the naked eye.
(B) Glassy - Composed entirely of coarse interlocking crystals.
(C) Aphanitic - Crystals are too small to be seen without a microscope.
(D) Porphyritic - Two distinct sizes of crystals (phenocrysts and groundmass).

17. A porphyritic texture in an igneous rock implies:
(A) A single, slow stage of cooling deep underground.

(B) A two-stage cooling history: slow cooling followed by rapid cooling.
(C) Very rapid quenching of lava on the seafloor.
(D) Post-crystallization alteration by hydrothermal fluids.

18. What does a poikilitic texture, where small crystals of one mineral are enclosed within a large crystal of another, indicate about crystallization history?
(A) The large host crystal crystallized later than the small enclosed crystals.
(B) Both minerals crystallized simultaneously from the available silicate melt.
(C) The small enclosed crystals crystallized later than the host crystal.
(D) The rock cooled so rapidly that no distinct crystal shapes could form.

19. Layered igneous intrusions are typically associated with which type of magma?
(A) Highly viscous rhyolitic magma.
(B) Water-rich granitic magma.
(C) Low-viscosity mafic or ultramafic magma.
(D) Carbonatite magma.

20. Which of the following is the best example of a layered igneous structure?
(A) The Deccan Traps, India
(B) The granite batholiths of the Sierra Nevada
(C) Mount St. Helens volcano, USA
(D) The Bushveld Complex, South Africa

21. A 'petrographic province' is a geographic area characterized by:
(A) Rocks of a similar age, regardless of composition.
(B) A specific type of metamorphic facies.
(C) Igneous rocks that are related by a common magmatic origin.
(D) The presence of a single, large batholith.

22. The process of 'granitization' proposes that granite can form:
(A) Exclusively from the crystallization of a felsic magma.
(B) Through extreme metamorphism and metasomatism without a fully molten stage.
(C) By the rapid cooling of basaltic lava in a subaqueous environment.
(D) From the accumulation of crystal-rich mushes in a magma chamber.

23. Which of the following statements about the origin of granite is correct?
(A) All granites are formed through the granitization of sediments.
(B) Granite can only form in oceanic crust settings.
(C) Anatexis is not considered a viable process for generating granitic magma.
(D) The magmatic origin theory suggests granite forms from the cooling of felsic magma.

24. The following question consists of two statements, an Assertion (A) and a Reason (R). Select the correct answer using the codes given below.
Assertion (A) : Basalt is a fine-grained, mafic igneous rock.
Reason (R) : Basalt typically forms from the rapid cooling of low-viscosity lava at or near the Earth's surface.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

25. The Deccan Traps in India are a vast province of which type of igneous rock?
(A) Granite
(B) Andesite
(C) Basalt
(D) Carbonatite

26. Which tectonic setting is most commonly associated with the generation of andesitic magmas?
(A) Convergent plate margins (subduction zones)
(B) Mid-ocean ridges
(C) Continental rift valleys
(D) Intraplate hotspots under continental crust

27. Carbonatites are unusual igneous rocks defined by having:
(A) More than 90% silicate minerals.
(B) A composition dominated by quartz and feldspar.
(C) A complete absence of feldspar minerals.

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(D) More than 50% carbonate minerals.

28. An Indian occurrence of carbonatite is found in which area?
(A) The Malani region of Rajasthan
(B) The Amba Dongar complex in Gujarat
(C) The Singhbhum craton in Jharkhand
(D) The Kolar schist belt in Karnataka

29. Alkaline igneous rocks are characterized by:
(A) A high concentration of silica leading to abundant quartz.
(B) The exclusive presence of plagioclase feldspar.
(C) A deficiency in silica relative to alkali components.
(D) A composition dominated by olivine and pyroxene.

30. Ultramafic rocks like peridotite and dunite are composed primarily of:
(A) Quartz and K-feldspar
(B) Plagioclase and amphibole
(C) Muscovite and biotite
(D) Olivine and pyroxene

31. Which of the following is considered the most significant agent of metamorphism?
(A) Temperature
(B) Gravity
(C) Wind
(D) Erosion

32. Given below are two statements regarding agents of metamorphism.
Statement I : Pressure during metamorphism can be either lithostatic (uniform) or directed.
Statement II : Hydrothermal fluids can act as catalysts, speeding up metamorphic reactions.
Which of the above statements is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

33. 'Regional metamorphism' is a kind of metamorphism typically associated with:
(A) The baking of country rock adjacent to an igneous intrusion.
(B) Large-scale mountain building and tectonism at convergent plate boundaries.
(C) The circulation of hot fluids through rock fractures.
(D) The impact of a meteorite.

34. The kind of metamorphism that occurs when a rock is altered by contact with a hot igneous body is called:
(A) Contact metamorphism
(B) Burial metamorphism
(C) Dynamic metamorphism
(D) Regional metamorphism

35. Which of the following types of metamorphism is characterized primarily by the effects of directed pressure (stress) along fault zones?
(A) Contact metamorphism
(B) Burial metamorphism
(C) Cataclastic or Dynamic metamorphism
(D) Hydrothermal metamorphism

36. Metamorphic differentiation is the process by which:
(A) An igneous rock differentiates into felsic and mafic components.
(B) A magma body separates into layers of different composition.
(C) Sediments are sorted by grain size during transport.
(D) A homogeneous parent rock develops mineralogical bands during metamorphism.

37. A gneissic texture in a metamorphic rock is characterized by:
(A) A very fine-grained, non-foliated appearance.
(B) The parallel alignment of platy minerals like mica.
(C) The segregation of minerals into light and dark bands.
(D) Large, porphyroblastic crystals in a fine-grained matrix.

38. Which of the following is an example of a foliated metamorphic texture?
(A) Hornfelsic
(B) Schistose
(C) Granoblastic
(D) Migmatitic

39. The term 'metamorphic zone' refers to a region:
(A) That has experienced a particular type of

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faulting.
(B) Where igneous intrusions are common.
(C) Defined by a specific depth below the Earth's surface.
(D) Characterized by a specific index mineral or mineral assemblage.

40. In the progressive metamorphism of a pelitic rock, which index mineral typically indicates the lowest grade of metamorphism?
(A) Chlorite
(B) Sillimanite
(C) Garnet
(D) Staurolite

41. Metamorphic grade refers to:
(A) The angle of foliation in a metamorphic rock.
(B) The economic value of the minerals within the rock.
(C) The intensity of metamorphism related to temperature and pressure.
(D) The percentage of mafic minerals in the rock.

42. Which sequence correctly lists metamorphic rocks from lowest to highest grade?
(A) Slate, Phyllite, Schist, Gneiss
(B) Gneiss, Schist, Phyllite, Slate
(C) Schist, Gneiss, Slate, Phyllite
(D) Phyllite, Slate, Gneiss, Schist

43. The concept of 'metamorphic facies' defines:
(A) The outward appearance or texture of a metamorphic rock.
(B) A geographic area with rocks of the same metamorphic grade.
(C) The chemical composition of the protolith.
(D) A set of mineral assemblages forming under specific P-T conditions.

44. Which metamorphic facies is characteristic of high-pressure, low-temperature conditions, typically found in subduction zones?
(A) Granulite facies
(B) Blueschist facies
(C) Amphibolite facies
(D) Greenschist facies

45. Metasomatism is a process of metamorphism that involves:
(A) Changes in pressure and temperature with no chemical change.
(B) Mechanical grinding and crushing of rock without mineral change.
(C) Significant change in bulk chemical composition due to fluid interaction.
(D) Partial melting of the rock to form a migmatite.

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46. Which of the following is NOT a type of metasomatism?
(A) Fenitization
(B) Greisenization
(C) Skarn formation
(D) Foliation

47. A migmatite is a composite rock that exhibits features of both:
(A) Metamorphic and igneous (or igneous-like) rocks
(B) Igneous and sedimentary rocks
(C) Volcanic and plutonic rocks
(D) Sedimentary and volcanic rocks

48. In a migmatite, the light-colored, granitic part is called the:
(A) Melanosome
(B) Leucosome
(C) Paleosome
(D) Restite

49. The metamorphism of a pure limestone (calcite) primarily results in the formation of:
(A) Slate
(B) Schist
(C) Marble
(D) Quartzite

50. The Barrovian zones of metamorphism were originally defined based on the progressive metamorphism of which rock type?
(A) Mafic rocks
(B) Carbonates
(C) Pelites (shales and mudstones)
(D) Ultramafic rocks

51. Match the Metamorphic Rocks in List I with their Protoliths in List II.
List I: (Metamorphic Rock)
P. Marble
Q. Quartzite

R. Slate
S. Greenstone
List II: (Protolith)
1. Shale
2. Sandstone
3. Limestone
4. Basalt
(A) P-3, Q-2, R-1, S-4
(B) P-1, Q-3, R-4, S-2
(C) P-3, Q-1, R-2, S-4
(D) P-2, Q-4, R-1, S-3

52. Charnockites are distinctive rocks of the granulite facies, characterized by the presence of:
(A) Muscovite and chlorite
(B) Glaucophane and lawsonite
(C) Orthopyroxene (hypersthene) in a granitic-composition rock
(D) Abundant staurolite and kyanite

53. Khondalites, typically found in the Eastern Ghats of India, are metamorphosed:
(A) Basaltic flows
(B) Impure limestones
(C) Alumina-rich sediments (pelites)
(D) Ultramafic intrusions

54. Which of the following statements about the origin of magma is incorrect?
(A) Magma can be generated by decompression melting at mid-ocean ridges.
(B) The addition of volatiles like water can lower the melting temperature of mantle rock.
(C) All magma originates from the complete melting of the Earth's outer core.
(D) Heat transfer from intruding magma can cause melting of surrounding crustal rocks.

55. In the context of phase equilibria, a binary system with a 'mixed' or 'solid solution' series, like Albite-Anorthite, is characterized by:
(A) The simultaneous crystallization of two minerals at a fixed temperature.
(B) A melting range where both liquid and solid can coexist.
(C) Incongruent melting where one mineral reacts to form another.
(D) A single, fixed melting point for all compositions.

56. Given below are two statements regarding phase equilibria and mineral reactions.
Statement I : The temperature at the peritectic point in a binary system is constant.
Statement II : In the Fo-Fa-Silica system, olivine can react with the melt to form pyroxene.
Which of the above statements is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

57. The IUGS classification for ultramafic rocks is primarily based on the relative proportions of:
(A) Quartz, Feldspar, and Mica
(B) Olivine, Orthopyroxene, and Clinopyroxene
(C) Plagioclase, Nepheline, and Leucite
(D) Garnet, Staurolite, and Kyanite

58. The continuous reaction series in Bowen's model describes the compositional change in which mineral group?
(A) Pyroxenes
(B) Amphiboles
(C) Plagioclase Feldspars
(D) Micas

59. A geologist observes a rock with large, well-formed crystals of amphibole surrounded by a fine-grained matrix of plagioclase and pyroxene. What is the most appropriate term for this texture?
(A) Granitic
(B) Schistose
(C) Porphyritic
(D) Gneissic

60. What is the primary mechanism responsible for forming the rhythmic layering seen in intrusions like the Skaergaard intrusion?
(A) Multiple injections of different magma compositions.
(B) Post-emplacement metamorphic differentiation.
(C) Crystal settling and fractional crystallization from a convecting magma chamber.
(D) The mixing of immiscible silicate and sulfide liquids.

61. Consider the following statements regarding the origin of granite:

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Statement I : The magmatic theory posits that granitic magma is generated by partial melting of continental crust.
Statement II : Granitization involves in-situ transformation of solid rock into granite via metasomatic processes.
Statement III: S-type granites are derived from the melting of sedimentary source rocks.
Which of the statements given above are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II and III

62. What is the plutonic equivalent of basalt?
(A) Granite
(B) Diorite
(C) Gabbro
(D) Peridotite

63. The presence of pillow lavas in a basaltic sequence is strong evidence for:
(A) Subaerial eruption onto a floodplain.
(B) Subaqueous (underwater) eruption.
(C) Very slow, intrusive cooling.
(D) High-grade metamorphism.

64. Andesite is named after the Andes Mountains, reflecting its common association with:
(A) Continental shield areas
(B) Oceanic islands
(C) Volcanic arcs on continental margins
(D) Mid-ocean ridges

65. The following question consists of two statements, an Assertion (A) and a Reason (R). Select the correct answer using the codes given below.
Assertion (A) : Alkaline rocks are often associated with continental rift environments.
Reason (R) : Rifting allows for low degrees of partial melting at great depths in the mantle, producing magmas that are undersaturated in silica and enriched in alkalis.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

66. Komatiites, a type of ultramafic volcanic rock, are characterized by a unique texture called:
(A) Ophitic
(B) Spinifex
(C) Trachytic
(D) Variolitic

67. Which of the following is a physical agent of metamorphism?
(A) Carbon dioxide
(B) Water
(C) Pressure
(D) Methane

68. Contact aureoles, zones of alteration surrounding an igneous intrusion, are the classic setting for which type of metamorphism?
(A) Regional
(B) Contact
(C) Dynamic
(D) Burial

69. Which texture is characteristic of dynamic metamorphism and involves the crushing and pulverization of rocks in a fault zone?
(A) Porphyroblastic
(B) Granoblastic
(C) Cataclastic
(D) Decussate

70. The development of alternating quartz-feldspar-rich and mica-rich layers in a high-grade metamorphic rock is an example of:
(A) Magmatic differentiation
(B) Metamorphic differentiation
(C) Sedimentary bedding
(D) Fractional crystallization

71. A metamorphic rock that is characterized by a strong parallel alignment of platy minerals, making it split easily into thin sheets, is called:
(A) Gneiss
(B) Schist
(C) Hornfels
(D) Marble

72. An isograd is a line on a geological map that connects points:
(A) Of equal elevation.
(B) Of equal magnetic intensity.
(C) Marking the first appearance of a particular

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index mineral.
(D) Of equal age of rock formation.

73. The amphibolite facies is indicative of what general conditions of metamorphism?
(A) High pressure and low temperature
(B) Low pressure and low temperature
(C) Medium to high temperature and medium pressure
(D) Very high temperature and variable pressure

74. Fenitization is a specific type of metasomatism associated with the intrusion of:
(A) Granites
(B) Basalts
(C) Carbonatites and alkaline rocks
(D) Ultramafic bodies

75. Arrange the following events in the crystallization of a binary eutectic system from a liquid state.
1. Liquid cools to the liquidus temperature.
2. Composition of the liquid changes as the first mineral crystallizes.
3. Both minerals crystallize simultaneously at the eutectic point.
4. Liquid composition reaches the eutectic composition.

Select the correct chronological order:
(A) 1, 2, 4, 3
(B) 1, 3, 2, 4
(C) 2, 1, 4, 3
(D) 4, 3, 1, 2

76. In a migmatite, the dark-colored, mafic-rich part representing the residual solid rock after partial melting is called the:
(A) Leucosome
(B) Melanosome or Restite
(C) Paleosome
(D) Neosome

77. The metamorphism of an impure, clay-rich dolomite would likely produce which characteristic metamorphic mineral?
(A) Quartz
(B) Talc or Tremolite
(C) Staurolite
(D) Sillimanite

78. The pair of minerals Kyanite-Sillimanite in a metamorphic rock indicates that the rock has crossed a boundary related to:
(A) A change in the bulk chemical composition.
(B) An increase in temperature at a certain pressure.
(C) A decrease in pressure with increasing water content.
(D) The onset of partial melting.

79. The charnockite rock series of Southern India is considered a classic example of:
(A) Blueschist facies metamorphism
(B) Greenschist facies metamorphism
(C) Granulite facies metamorphism
(D) Zeolite facies metamorphism

80. A key mineralogical characteristic of a Khondalite is the presence of:
(A) Olivine and Pyroxene
(B) Garnet, Sillimanite, and Graphite
(C) Glaucophane and Lawsonite
(D) Hornblende and Plagioclase

81. Magma assimilation is limited by which factor?
(A) The viscosity of the magma.
(B) The volume of the magma chamber.
(C) The thermal energy available for melting.
(D) The depth of the magma chamber.

82. In the binary phase diagram for Forsterite (Fo) and Fayalite (Fa), the system exhibits:
(A) A eutectic point
(B) A peritectic point
(C) Complete solid solution
(D) Immiscibility in the liquid state

83. Which statement about the IUGS QAPF diagram is incorrect?
(A) It cannot be used for rocks with more than 90% mafic minerals.
(B) The vertices are Quartz, Alkali Feldspar, Plagioclase, and Feldspathoid.
(C) It is designed for both volcanic and plutonic rocks using different diagrams.
(D) It classifies rocks based on their color index.

84. The 'reaction rim' texture, where a crystal of one mineral is surrounded by a rim of a second mineral, is a direct microscopic evidence of:
(A) Bowen's Reaction Principle

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(B) Metamorphic differentiation
(C) Magma mingling
(D) Cataclasis

85. A vesicular texture in a volcanic rock like pumice is caused by:
(A) The slow growth of interlocking crystals.
(B) The rapid escape of dissolved gas bubbles.
(C) The alteration of the rock by hot water.
(D) The mechanical fragmentation of the rock.

86. The Malani Igneous Suite in India is a well-known example of a:
(A) Layered mafic intrusion
(B) Large Igneous Province (LIP) of basaltic composition
(C) Bimodal (felsic and mafic) anorogenic magmatic province
(D) Carbonatite complex

87. Which of the following is NOT a common petrographic feature of basalt?
(A) Fine-grained groundmass
(B) Presence of olivine, pyroxene, and plagioclase
(C) Abundant quartz and muscovite
(D) Ophitic or sub-ophitic texture

88. 'Granitization' is a controversial process because:
(A) It violates the laws of thermodynamics.
(B) It requires large-scale transfer of materials.
(C) It can only occur on other planets, not Earth.
(D) It only explains the formation of mafic rocks, not granite.

89. Match the Rock Types in List I with their Dominant Minerals in List II.
List I: (Rock Type)
P. Anorthosite
Q. Dunite
R. Syenite
S. Carbonatite
List II: (Dominant Minerals)
1. Olivine
2. Calcite/Dolomite
3. Alkali Feldspar
4. Plagioclase
(A) P-1, Q-4, R-2, S-3
(B) P-4, Q-1, R-3, S-2
(C) P-4, Q-2, R-3, S-1
(D) P-1, Q-3, R-2, S-4

90. The agents of metamorphism are primarily Heat, Pressure, and:
(A) Erosion
(B) Tectonically active fluids
(C) Gravity
(D) Sedimentation

91. What is the primary difference between 'kinds' of metamorphism and 'types' of metamorphism?
(A) There is no difference; the terms are interchangeable.
(B) 'Kinds' refer to geological settings; 'types' refer to P-T changes.
(C) 'Kinds' refer to chemical changes; 'types' refer to physical changes.
(D) 'Kinds' apply to low-grade rocks; 'types' apply to high-grade rocks.

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92. A granoblastic texture, characterized by equigranular, anhedral crystals, is typical of which type of metamorphic rock?
(A) Slate, which is highly foliated
(B) Schist, with aligned micas
(C) Marble or Quartzite, which are monomineralic
(D) Gneiss, with compositional banding

93. The concept of metamorphic zones, using index minerals, works best for which type of protolith?
(A) Pure quartzite, because it is monomineralic.
(B) Pelites, because their chemistry allows many minerals.
(C) Pure limestone, which recrystallizes easily.
(D) Basalt, which has a simple chemical composition.

94. Which metamorphic facies represents the highest temperature and pressure conditions of regional metamorphism?
(A) Greenschist facies
(B) Amphibolite facies
(C) Granulite facies
(D) Blueschist facies

95. What is the process called where an existing metamorphic mineral assemblage reacts to form a lower-grade assemblage?
(A) Prograde metamorphism
(B) Anatexis

(C) Retrograde metamorphism
(D) Metasomatism

96. The formation of skarns is a type of contact metasomatism that occurs when a magma intrudes into:
(A) Shale or mudstone
(B) Carbonate rocks like limestone or dolostone
(C) Sandstone
(D) Basalt

97. Migmatites represent the transition between:
(A) Sedimentary and metamorphic rocks
(B) High-grade metamorphism and magmatism
(C) Plutonic and volcanic igneous rocks
(D) Low-grade and medium-grade metamorphism

98. The metamorphism of mafic rocks at greenschist facies conditions produces a rock commonly called:
(A) Blueschist
(B) Eclogite
(C) Greenschist or Greenstone
(D) Amphibolite

99. Charnockite is often referred to as:
(A) A pyroxene-bearing granite
(B) A garnet-rich pelite
(C) A retrogressed eclogite
(D) A contact-metamorphosed basalt

100. Given below are two statements regarding Khondalites.
Statement I : They are part of a high-grade metamorphic terrain.
Statement II : Their protolith was likely an aluminous sediment.
Which of the above statements is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

101. Arrange the following minerals of the discontinuous reaction series in their correct order of crystallization from a cooling magma.
1. Amphibole
2. Olivine
3. Biotite Mica
4. Pyroxene

Select the correct chronological order:
(A) 2, 1, 4, 3
(B) 2, 4, 1, 3
(C) 1, 2, 3, 4
(D) 4, 1, 3, 2

102. The following question consists of two statements, an Assertion (A) and a Reason (R). Select the correct answer using the codes given below.
Assertion (A) : The texture of an igneous rock provides clues about its cooling history.
Reason (R) : Slow cooling allows for the growth of large crystals, while rapid cooling results in small or no crystals.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

103. Which of the following is NOT a factor affecting the composition of a primary magma?
(A) The composition of the source rock.
(B) The temperature and pressure of partial melting.
(C) The presence or absence of volatiles.
(D) The rate of weathering of the overlying rock.

104. Consider the following statements about metamorphic facies:
Statement I : A metamorphic facies is defined by a single specific mineral.
Statement II : All rocks within a given facies must have experienced the same P-T conditions.
Statement III: The mineral assemblage of a facies depends on the protolith composition.
Which of the statements given above are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II and III

105. In the ternary Ab-An-Di system, the lowest temperature on the liquidus surface is found at the:
(A) Ab-An binary eutectic
(B) Ab-Di-An ternary eutectic
(C) Di-An binary eutectic

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(D) Albite corner

106. A rock composed almost entirely of olivine is called:
(A) Anorthosite
(B) Gabbro
(C) Dunite
(D) Syenite

107. Which kind of metamorphism would you most expect to find at a mid-ocean ridge?
(A) Regional metamorphism
(B) Hydrothermal metamorphism
(C) Dynamic metamorphism
(D) Burial metamorphism

108. Which pair correctly links a metamorphic texture with its description?
(A) Slaty cleavage - Interlocking equigranular crystals.
(B) Gneissic banding - Parallel alignment of platy minerals only.
(C) Hornfelsic - Fine-grained, non-foliated, equigranular.
(D) Schistosity - Crushing and pulverization of grains.

109. The metamorphism of a basalt protolith at high pressures and temperatures results in a rock called:
(A) Marble
(B) Quartzite
(C) Metabasite or Amphibolite
(D) Pelitic Schist

110. In a migmatite, the 'paleosome' refers to:
(A) The newly formed granitic melt.
(B) The dark, residual solid.
(C) The unaffected or less-affected protolith material.
(D) The entire migmatitic rock.

111. Which of the following defines magmatic evolution by differentiation?
(A) Separation of crystals from a liquid melt to form a different residual melt.
(B) Incorporation of wall rock into the magma.
(C) Mixing of two different magmas.
(D) Complete melting of a source rock at once.

112. The presence of leucite or nepheline in an igneous rock indicates that the parent magma was:
(A) Silica-oversaturated
(B) Silica-undersaturated
(C) Silica-saturated
(D) A tholeiitic basalt

113. An ophitic texture, where laths of plagioclase are enclosed by larger crystals of pyroxene, is characteristic of which rock?
(A) Granite
(B) Rhyolite
(C) Dolerite or Diabase
(D) Peridotite

114. A geologist identifies a large petrographic province composed of flood basalts, a radiating dyke swarm, and a mantle plume trace. This is characteristic of a:
(A) Subduction zone complex
(B) Large Igneous Province (LIP)
(C) Fold-and-thrust belt
(D) Passive continental margin

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115. Which process is NOT associated with the magmatic origin of granite?
(A) Fractional crystallization of basaltic magma.
(B) Partial melting of continental crust (anatexis).
(C) In-situ replacement of sedimentary rocks by metasomatic fluids.
(D) Magma mixing between mafic and felsic melts.

116. A key petrographic feature of many andesites is:
(A) Spinifex texture.
(B) Zoned plagioclase phenocrysts in a fine-grained groundmass.
(C) Abundant leucite and nepheline.
(D) Gneissic banding.

117. Which of the following is a type of ultramafic rock?
(A) Andesite
(B) Dacite
(C) Peridotite
(D) Trachyte

118. Match the Metamorphic Facies in List I with their Characteristic Mineral/Assemblage in List II.

List I: (Metamorphic Facies)

P. Blueschist
Q. Eclogite
R. Greenschist
S. Granulite

List II: (Characteristic Mineral/Assemblage)

1. Chlorite + Albite + Epidote
2. Orthopyroxene + Clinopyroxene + Plagioclase
3. Glaucophane + Lawsonite
4. Omphacite + Garnet

(A) P-1, Q-2, R-4, S-3
(B) P-3, Q-4, R-1, S-2
(C) P-3, Q-1, R-2, S-4
(D) P-1, Q-4, R-3, S-2

119. Retrograde metamorphism is often limited or incomplete because:
(A) The required high temperatures are not available.
(B) Reactions are slow and require fluids driven off during prograde stages.
(C) The pressure is too high for the reactions to proceed.
(D) It only happens at the Earth's surface.

120. In the metamorphism of pelitic rocks, which mineral is a key indicator of high pressure?
(A) Andalusite
(B) Kyanite
(C) Sillimanite
(D) Cordierite

121. What is the fundamental difference between magma and lava?
(A) Magma is felsic, while lava is mafic.
(B) Magma is molten rock below the surface; lava is on the surface.
(C) Magma contains crystals, while lava is pure liquid.
(D) Magma forms plutonic rocks; lava forms metamorphic rocks.

122. Crystal settling is a mechanism of magmatic differentiation where:
(A) Early-formed, denser crystals sink through the less dense liquid magma.
(B) Liquid is squeezed out from a crystal-liquid mush.
(C) The magma chamber is refilled with fresh, hot magma.
(D) The magma assimilate and melts surrounding rocks.

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123. The point on a phase diagram representing the temperature and composition at which a solid phase reacts with the liquid to produce a new solid phase is called a:
(A) Eutectic point
(B) Peritectic point
(C) Cotectic line
(D) Triple point

124. In the QAPF diagram for plutonic rocks, a rock plotting at the 'A' vertex would be classified as:
(A) Quartzolite
(B) Alkali-feldspar syenite
(C) Anorthosite
(D) Foidite

125. Given below are two statements regarding Bowen's Reaction Series.
Statement I : It predicts the order of mineral stability in weathering at the Earth's surface.
Statement II : It accurately represents the crystallization sequence of all magma types.
Which of the above statements is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

126. What is the most likely crystallization history of a rock with a seriate texture?
(A) Two distinct stages of cooling.
(B) A single, uninterrupted, and moderately slow cooling period.
(C) Extremely rapid quenching.
(D) Post-emplacement recrystallization.

127. Which of the following is NOT a characteristic of a layered igneous intrusion?
(A) Typically mafic or ultramafic in composition.
(B) Often show rhythmic and cryptic layering.
(C) Formed by rapid, subaerial volcanic eruptions.
(D) Can host significant ore deposits of Cr, Ni, and PGE.

(D) A specific chemical reaction in a metamorphic rock.

219. The transformation of a rock by the introduction of new chemical species via a fluid phase is called:
(A) Anatexis
(B) Isochemical metamorphism
(C) Metasomatism
(D) Cataclasis

220. The metamorphism of pure dolomite results in a rock composed of dolomite crystals called:
(A) Dolomitic marble
(B) Skarn
(C) Brucite marble
(D) Calciphyre

221. Arrange the following events in the evolution of a magma chamber that undergoes fractional crystallization and assimilation.
1. Intrusion of primary magma.
2. Settling of early-formed mafic crystals.
3. Incorporation and melting of felsic country rock.
4. Eruption of an evolved, more silica-rich magma.

Select the correct chronological order:
(A) 1, 3, 2, 4
(B) 1, 2, 3, 4
(C) 3, 1, 2, 4
(D) 2, 1, 3, 4

222. Which of the following statements about the origin of granite is a key argument for the 'granitization' theory?
(A) The existence of sharp, intrusive contacts between granite and country rock.
(B) Observation of gradational contacts and 'ghost' stratigraphy in granite bodies.
(C) The presence of chilled margins in granite plutons.
(D) The chemical similarity between experimental melts and natural granites.

223. The mineral glaucophane is a key indicator of which metamorphic facies?
(A) Greenschist
(B) Amphibolite
(C) Blueschist
(D) Granulite

224. A rock showing distinct compositional banding, with felsic leucosome parts and mafic melanosome parts, is a:
(A) Layered gabbro
(B) Banded iron formation
(C) Migmatite
(D) Mylonite

225. The following question consists of two statements, an Assertion (A) and a Reason (R). Select the correct answer using the codes given below.
Assertion (A) : Charnockites are considered products of 'dry' metamorphism at high temperatures.
Reason (R) : Their mineralogy, featuring orthopyroxene and lacking hydrous minerals, indicates granulite-facies conditions.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

226. The primary difference between magma differentiation and assimilation is that differentiation involves ___, while assimilation involves ___.
(A) internal processes; external material addition
(B) external material addition; internal processes
(C) only temperature changes; only pressure changes
(D) only felsic magmas; only mafic magmas

227. In phase equilibria, the number of components (C), phases (P), and degrees of freedom (F) are related by the Gibbs' Phase Rule, which is:
(A) $P + C = F + 2$
(B) $C + F = P + 1$
(C) $P + F = C + 2$
(D) $F = C - P$

228. In the IUGS classification, a plutonic rock composed of 95% plagioclase would be called:
(A) Gabbro
(B) Diorite
(C) Syenite
(D) Anorthosite

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138. The term 'ophiolite' refers to a sequence of rocks believed to represent a fragment of:
(A) Continental crust
(B) A large igneous province
(C) Oceanic crust and upper mantle
(D) A subduction zone accretionary wedge

139. In the context of migmatites, what does 'anatexis' mean?
(A) Complete melting of a rock
(B) Partial melting of a rock
(C) Recrystallization without melting
(D) Chemical alteration by fluids

140. Which of the following is NOT an ultramafic rock?
(A) Peridotite
(B) Dunite
(C) Pyroxenite
(D) Gabbro

141. The origin of magma at divergent plate boundaries is best explained by:
(A) Decompression melting
(B) Flux melting due to addition of water
(C) Heat transfer from adjacent magma bodies
(D) An increase in pressure

142. The process of filter pressing involves:
(A) Denser crystals sinking through magma.
(B) The squeezing of interstitial liquid from a crystal mush.
(C) The floating of less dense crystals.
(D) The mixing of two distinct magmas.

143. In the Fo-Fa-Silica ternary diagram, the boundary line separating the primary crystallization fields of olivine and pyroxene represents a:
(A) Eutectic reaction
(B) Cotectic reaction
(C) Peritectic reaction
(D) Solid solution loop

144. According to the IUGS classification, a volcanic rock that is fine-grained and has the same mineral composition as granite is called:
(A) Basalt
(B) Andesite
(C) Rhyolite
(D) Diorite

145. What is a 'reaction series' in igneous petrology?
(A) A series of chemical reactions that weather a rock.
(B) A predictable sequence of mineral crystallization from a cooling magma.
(C) A series of metamorphic reactions.
(D) A sequence of magma compositions erupted from a volcano.

146. A graphic texture, with an intergrowth of quartz and alkali feldspar resembling ancient writing, is a specific type of:
(A) Granophyric or Eutectic texture
(B) Porphyritic texture
(C) Vesicular texture
(D) Poikilitic texture

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147. Cryptic layering in a layered intrusion refers to:
(A) The visible alternation of light and dark mineral layers.
(B) Systematic variation in mineral chemical composition with height.
(C) Layers that are hidden and only visible with geophysical methods.
(D) Small-scale cross-bedding structures formed by magma currents.

148. S-type (sedimentary protolith) granites are typically:
(A) Metaluminous
(B) Peralkaline
(C) Silica-undersaturated
(D) Peraluminous

149. The petrogenesis of andesite in subduction zones is often explained by:
(A) Direct melting of the subducting oceanic crust.
(B) Partial melting of the metasomatized mantle wedge.
(C) Fractional crystallization of ultramafic magma.
(D) Complete melting of continental sediments.

150. Indian occurrences of alkaline rocks are notably found in:
(A) The Deccan Traps region
(B) The Eastern Ghats Belt and the Aravalli Craton
(C) The Himalayan mountain range
(D) The Andaman and Nicobar Islands

(A) The Closepet Granite
(B) The Nidar Ophiolite of Ladakh
(C) The Amba Dongar Carbonatite
(D) The Malani Rhyolites

197. Burial metamorphism is characterized by:
(A) High temperatures and low pressures.
(B) High directed stress in fault zones.
(C) Increasing temperature and lithostatic pressure from deep burial.
(D) The circulation of hot water.

198. Given below are two statements regarding mechanical deformation and dynamic metamorphism.
Statement I : Cataclastic metamorphism is dominated by mechanical deformation.
Statement II : Mylonites are rocks formed under intense shear stress during dynamic metamorphism.
Which of the above statements is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

199. A 'porphyroclast' in a metamorphic rock is:
(A) A newly grown large crystal.
(B) A fragment of a pre-existing large crystal that has been deformed.
(C) A small crystal enclosed in a larger one.
(D) A mineral indicating a specific metamorphic grade.

200. What does the presence of andalusite, kyanite, and sillimanite together signify?
(A) A unique pressure and temperature condition (~5.5 kbar, ~600°C).
(B) The onset of retrograde metamorphism.
(C) The rock is a migmatite.
(D) The protolith was extremely rich in aluminum.

201. Match the Igneous Rocks in List I with their Typical Tectonic Settings in List II.
List I: (Igneous Rock)
P. Basalt
Q. Andesite
R. Granite
S. Alkaline Rocks
List II: (Typical Tectonic Setting)
1. Continental Collision/Intraplate
2. Subduction Zone
3. Mid-Ocean Ridge/Hotspot
4. Continental Rift
(A) P-1, Q-2, R-4, S-3
(B) P-3, Q-2, R-1, S-4
(C) P-3, Q-4, R-1, S-2
(D) P-2, Q-1, R-4, S-3

202. The following question consists of two statements, an Assertion (A) and a Reason (R). Select the correct answer using the codes given below.
Assertion (A) : The final liquid to crystallize in the ternary Ab-An-Di system is at the ternary eutectic point.
Reason (R) : This point represents the lowest temperature at which liquid can exist in the system.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

203. 'Reaction Principle' was a concept put forward by:
(A) Alfred Wegener
(B) N. L. Bowen
(C) James Hutton
(D) Charles Lyell

204. Consider the following statements regarding igneous textures:
Statement I : A phaneritic texture indicates intrusive origin.
Statement II : A glassy texture indicates extrusive origin.
Statement III: A porphyritic texture can indicate a complex, multi-stage cooling history.
Which of the statements given above are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II and III

205. The process of granitization is best described as an extreme form of:
(A) Magmatic differentiation
(B) Regional metamorphism

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(C) Two separate stages of cooling.
(D) High water content in the magma.

161. What is the most distinguishing feature of a carbonatite?
(A) Its high silica content.
(B) Its primary mineralogy contains more than 50% carbonate minerals.
(C) It is always a volcanic rock.
(D) It is only found in oceanic settings.

162. Directed pressure (stress) as an agent of metamorphism is responsible for the development of:
(A) Granoblastic textures
(B) Hornfelsic textures
(C) Foliation
(D) Porphyroblasts

163. A 'contact aureole' is:
(A) A zone of altered rock surrounding an igneous intrusion.
(B) The boundary between two tectonic plates.
(C) A circular feature caused by meteorite impact.
(D) A layer within a stratified volcanic eruption.

164. What is the protolith of a quartzite?
(A) Limestone
(B) Shale
(C) Pure quartz sandstone
(D) Basalt

165. The presence of omphacite and pyrope-rich garnet is characteristic of which metamorphic facies?
(A) Greenschist
(B) Amphibolite
(C) Blueschist
(D) Eclogite

166. A stromatic structure is a common type of:
(A) Metamorphic foliation
(B) Migmatite structure
(C) Sedimentary bedding
(D) Igneous flow banding

167. Which of the following statements about the metamorphism of pelites is correct?
(A) Pelites are insensitive to changes in temperature and pressure.
(B) The sequence chlorite → biotite → garnet → staurolite → kyanite → sillimanite represents increasing metamorphic grade.
(C) Metamorphosed pelites are always non-foliated.
(D) The only mineral to form during pelite metamorphism is quartz.

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168. The term Charnockite Series was first defined by T.H. Holland from occurrences near:
(A) Kolar Gold Fields, Karnataka
(B) Singhbhum, Jharkhand
(C) St. Thomas Mount, Madras
(D) Amba Dongar, Gujarat

169. Which factor is most critical in flux melting?
(A) A decrease in pressure.
(B) An increase in temperature from friction.
(C) The addition of volatiles from the subducting slab.
(D) The radioactive decay of elements in the mantle wedge.

170. Consider the following statements about magma evolution:
Statement I : Assimilation always makes a magma more mafic.
Statement II : Fractional crystallization of a basaltic magma typically makes the residual liquid more felsic.
Statement III: Magma mixing is a process where a single magma body separates into two immiscible liquids.
Which of the statements given above is/are correct?
(A) I only
(B) II only
(C) I and III only
(D) II and III only

171. In a binary phase diagram with a peritectic point, what happens during equilibrium cooling when the liquid composition reaches the peritectic?
(A) The liquid solidifies into two solids simultaneously.
(B) The early-formed solid reacts with the liquid to form a new solid phase.
(C) The liquid continues to cool without any phase change.
(D) The solid completely melts back into the liquid.

128. What is the defining characteristic of carbonatite magmas?
(A) High silica content
(B) Extremely high viscosity
(C) Low eruption temperatures and high volatile content
(D) Absence of any crystalline phases

129. Greisenization is a type of metasomatism that results in a rock rich in quartz and mica and is associated with:
(A) Carbonatite intrusions
(B) Granitic intrusions
(C) Mafic dykes
(D) Submarine basalts

130. The sequence Slate → Phyllite → Schist represents:
(A) Decreasing metamorphic grade.
(B) Increasing grain size and degree of foliation.
(C) A change in protolith composition from mafic to felsic.
(D) A path of retrograde metamorphism.

131. The concept that a single protolith composition can produce different metamorphic mineral assemblages under different P-T conditions is the basis for:
(A) Metamorphic zones
(B) The law of superposition
(C) Metamorphic facies
(D) Bowen's reaction series

132. Consider the following statements about characteristic metamorphic rocks:
Statement I : Charnockite is a hypersthene-bearing granite found in granulite facies terrains.
Statement II : Khondalite is a metamorphosed aluminous sediment, often containing garnet and sillimanite.
Statement III: Both charnockites and khondalites are characteristic rocks of low-grade metamorphic terrains.
Which of the statements given above are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II and III

133. The pressure experienced by a rock due to the weight of the overlying rock column is called:
(A) Directed pressure
(B) Shear stress
(C) Lithostatic pressure
(D) Fluid pressure

134. The following question consists of two statements, an Assertion (A) and a Reason (R). Select the correct answer using the codes given below.
Assertion (A) : In the Ab-An binary system, fractional crystallization of a melt will produce a final liquid enriched in the Ab component.
Reason (R) : The An component (anorthite) has a higher melting point and crystallizes at higher temperatures than the Ab component (albite).
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

135. What is the most abundant volcanic rock on Earth, forming the bulk of the oceanic crust?
(A) Andesite
(B) Rhyolite
(C) Basalt
(D) Komatiite

136. Arrange the following metamorphic facies in order of increasing temperature for a typical medium-pressure sequence.
1. Amphibolite
2. Granulite
3. Greenschist
4. Zeolite

Select the correct chronological order:
(A) 4, 3, 1, 2
(B) 3, 4, 1, 2
(C) 4, 1, 3, 2
(D) 1, 2, 3, 4

137. Which of the following minerals is a polymorph of Al_2SiO_5 and is indicative of low-pressure, high-temperature metamorphism?
(A) Kyanite
(B) Sillimanite
(C) Andalusite
(D) Staurolite

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184. A cumulate texture in an igneous rock implies that it formed by:
(A) Rapid quenching of a lava flow.
(B) The accumulation of crystals that settled from a magma.
(C) Metasomatic alteration of a pre-existing rock.
(D) Partial melting of a metamorphic rock.

185. A porphyroblastic texture is a metamorphic texture characterized by:
(A) The parallel alignment of platy minerals.
(B) The segregation of minerals into light and dark bands.
(C) Large metamorphic crystals in a finer-grained matrix.
(D) Fine-grained, non-foliated interlocking crystals.

186. Which of the following statements about metamorphic differentiation is incorrect?
(A) It can result in the formation of gneissic banding.
(B) It requires an initial homogeneous protolith to be most apparent.
(C) It is a process that homogenizes the rock composition.
(D) Pressure solution is one possible mechanism.

187. The eclogite facies is stable under which conditions?
(A) Low temperature, low pressure
(B) High temperature, low pressure
(C) Low temperature, high pressure
(D) High temperature, high pressure

188. Agmatite and schollen are terms used to describe structures within which type of rock?
(A) Layered intrusions
(B) Migmatites
(C) Pillow basalts
(D) Volcanic tuffs

189. During the prograde metamorphism of a typical mafic rock, what is the general sequence of facies?
(A) Greenschist → Amphibolite → Granulite
(B) Blueschist → Greenschist → Eclogite
(C) Zeolite → Granulite → Amphibolite
(D) Amphibolite → Greenschist → Blueschist

190. What is a key mineralogical feature of a khondalite?
(A) Presence of hypersthene and feldspar.
(B) Abundance of calcite and dolomite.
(C) The assemblage of garnet-sillimanite-graphite.
(D) The presence of glaucophane and lawsonite.

191. Liquid immiscibility in magmas refers to:
(A) The inability of a magma to mix with groundwater.
(B) The separation of a magma into coexisting liquids of different compositions.
(C) The process of crystals settling out of a magma.
(D) The complete solidification of magma at a single temperature.

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192. Which of the following minerals is stable at the lowest temperature according to Bowen's Reaction Series?
(A) Olivine
(B) Pyroxene
(C) Amphibole
(D) Quartz

193. The texture where laths of a mineral are randomly oriented within a finer-grained groundmass is called:
(A) Trachytic
(B) Poikilitic
(C) Spherulitic
(D) Pilotaxitic

194. The Bushveld Complex in South Africa is renowned for its vast resources of:
(A) Iron and Aluminum
(B) Platinum Group Elements, Chromium, and Vanadium
(C) Gold and Diamonds
(D) Uranium and Thorium

195. An 'I-type' granite is believed to be derived from:
(A) The melting of a sedimentary source rock.
(B) The melting of an igneous source rock.
(C) Metasomatic alteration of limestone.
(D) Fractional crystallization of a carbonatite magma.

196. Which Indian rock formation is a prominent example of an ultramafic body?

172. The term 'consanguineous' used to describe a petrographic province implies that the rocks:
(A) Are of the same age
(B) Have a common parental magma source
(C) Are found in the same geographic location
(D) Have the same texture

173. The 'granitization' hypothesis suggests that granite can form in the solid state through:
(A) Fractional crystallization
(B) Metasomatic replacement
(C) Decompression melting
(D) Magma mingling

174. Which major Indian geological feature is a classic example of a flood basalt province?
(A) The Himalayas
(B) The Aravalli Range
(C) The Deccan Traps
(D) The Eastern Ghats

175. The type of metamorphism that occurs over vast areas and is associated with mountain building is called:
(A) Contact metamorphism
(B) Regional metamorphism
(C) Cataclastic metamorphism
(D) Burial metamorphism

176. Which of the following represents an isochemical process?
(A) Metasomatism
(B) Most forms of prograde metamorphism
(C) Assimilation
(D) Granitization

177. Match the Index Minerals in List I with their Associated Metamorphic Zones/Grades in List II.
List I: (Index Mineral)
P. Chlorite
Q. Sillimanite
R. Staurolite
S. Glaucophane
List II: (Associated Metamorphic Zone/Grade)
1. High Grade (High T)
2. Medium Grade
3. Low Grade
4. High Pressure / Low Temperature
(A) P-3, Q-1, R-2, S-4
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-4, R-2, S-1
(D) P-4, Q-1, R-2, S-3

178. What type of rock is formed by the metamorphism of mafic igneous rocks?
(A) A metacarbonate
(B) A metapelite
(C) A metabasite
(D) A metaquartzite

179. A gneissic rock with orthopyroxene in place of biotite and hornblende is most likely a:
(A) Khondalite
(B) Migmatite
(C) Charnockite
(D) Eclogite

180. The primary agents of metamorphism are:
(A) Heat, erosion, and sedimentation
(B) Pressure, diagenesis, and weathering
(C) Heat, pressure, and chemically active fluids
(D) Time, temperature, and transport

181. Arrange the following igneous rocks in order of increasing silica content.
1. Granite
2. Gabbro
3. Peridotite
4. Diorite
Select the correct order:
(A) 3, 2, 4, 1
(B) 1, 4, 2, 3
(C) 3, 1, 2, 4
(D) 2, 3, 4, 1

182. In the Fo-Fa-Silica system, if a melt cools and crystallizes olivine, and the melt composition moves towards the silica apex, what might happen at the peritectic boundary?
(A) Olivine will continue to crystallize.
(B) The melt will solidify completely.
(C) Olivine will start to react with the melt to form pyroxene.
(D) A second, immiscible liquid will form.

183. The IUGS classification is not suitable for which of the following rock types?
(A) Granite and Gabbro
(B) Syenite and Diorite
(C) Carbonatites and Lamprophyres
(D) Rhyolite and Andesite

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(C) Metasomatism
(D) Anatexis

206. In India, occurrences of Basalt are most famously associated with:
(A) The Singhbhum Craton
(B) The Deccan Plateau
(C) The Aravalli Mountains
(D) The Himalayas

207. Which type of metamorphism is responsible for the formation of mylonites?
(A) Contact
(B) Burial
(C) Dynamic
(D) Regional

208. The term for the planar fabric in a metamorphic rock is:
(A) Lineation
(B) Foliation
(C) Granulation
(D) Boudinage

209. The Barrovian sequence of metamorphic zones is an example of what type of pressure-temperature path?
(A) High P / Low T
(B) Medium P / Medium T
(C) Low P / High T
(D) Very High P / High T

210. The formation of a migmatite requires temperatures high enough to cause:
(A) Recrystallization of calcite.
(B) The chlorite-to-biotite reaction.
(C) Partial melting of the host rock.
(D) The formation of glaucophane.

211. Which factor primarily controls the viscosity of a magma?
(A) Silica content and temperature
(B) Color
(C) Age
(D) Geographic location

212. In a binary system with a simple eutectic, if the starting liquid composition is exactly the eutectic composition, what happens upon cooling?
(A) Only one solid phase crystallizes until the liquid is consumed.
(B) The liquid solidifies at a constant temperature as a fine-grained intergrowth.
(C) The liquid cools below the eutectic temperature before solidifying.
(D) The two components separate into immiscible liquids.

213. A rock classified as a foidite in the IUGS system must contain:
(A) Between 10% and 60% feldspathoid minerals.
(B) More than 20% quartz.
(C) More than 90% mafic minerals.
(D) More than 60% feldspathoid minerals.

214. The continuous change in the composition of plagioclase feldspar from Ca-rich to Na-rich during cooling is an example of the:
(A) Discontinuous reaction series.
(B) Eutectic crystallization.
(C) Continuous reaction series.
(D) Peritectic reaction.

215. A cumulus phase in a layered intrusion refers to:
(A) The residual liquid after crystallization.
(B) The country rock assimilated by the magma.
(C) A later, separate injection of magma.
(D) Minerals that crystallized and accumulated, usually by settling.

216. The Malani Igneous Suite of Rajasthan is a significant petrographic province in India known for its:
(A) Ultramafic rocks and chromite deposits.
(B) Anorogenic, A-type granites and rhyolites.
(C) Flood basalts and dyke swarms.
(D) Blueschist and eclogite facies rocks.

217. A hornfels is a rock type typically formed by:
(A) High-pressure regional metamorphism.
(B) Dynamic metamorphism in a fault zone.
(C) High-temperature, low-pressure contact metamorphism.
(D) Hydrothermal alteration at a mid-ocean ridge.

218. An 'isograd' represents:
(A) A line of equal metamorphic grade.
(B) A boundary between facies on a P-T diagram.
(C) A line connecting points of first appearance of an index mineral.

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151. Match the Terms in List I with their Definitions in List II.
List I: (Term)
P. Protolith
Q. Isograd
R. Index Mineral
S. Metamorphic Grade
List II: (Definition)
1. A mineral whose appearance marks a specific set of P-T conditions.
2. The original, unmetamorphosed rock.
3. The intensity of metamorphism.
4. A line on a map of the first appearance of an index mineral.
(A) P-2, Q-4, R-1, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-3, R-4, S-1
(D) P-3, Q-4, R-1, S-2

152. Which of the following is a non-foliated metamorphic rock?
(A) Gneiss
(B) Schist
(C) Phyllite
(D) Hornfels

153. A rock containing the mineral assemblage glaucophane + lawsonite belongs to which metamorphic facies?
(A) Greenschist
(B) Amphibolite
(C) Blueschist
(D) Granulite

154. What is the primary difference between marble and quartzite?
(A) Their metamorphic grade.
(B) Their texture.
(C) Their protolith and mineral composition.
(D) Their foliation.

155. The following question consists of two statements, an Assertion (A) and a Reason (R). Select the correct answer using the codes given below.
Assertion (A) : Khondalites are considered to be high-grade supracrustal rocks.
Reason (R) : They are interpreted as metamorphosed sediments, specifically alumina-rich shales, indicating they were deposited at the surface before burial.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

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156. The change in magma composition due to the mixing of two chemically distinct magmas is called:
(A) Assimilation
(B) Fractional crystallization
(C) Magma mingling/mixing
(D) Liquid immiscibility

157. A eutectic system is one in which:
(A) The components are completely miscible in the solid state.
(B) A liquid of a specific composition freezes at a constant temperature.
(C) A solid melts incongruently to form a new solid and a liquid.
(D) The components are immiscible in the liquid state.

158. Which of the following is NOT a feldspathoid mineral used in the IUGS classification?
(A) Nepheline
(B) Leucite
(C) Sodalite
(D) Olivine

159. Given below are two statements regarding mineral reaction series.
Statement I : The discontinuous reaction series involves minerals with different crystal structures.
Statement II : The continuous reaction series involves minerals with the same crystal structure but varying chemical composition.
Which of the above statements is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

160. What does a glassy texture indicate about the cooling of a magma?
(A) Very slow cooling deep in the crust.
(B) Cooling was so rapid that no time for crystal formation occurred.

229. A rock texture with euhedral phenocrysts in an aphanitic groundmass is called:
(A) Equigranular
(B) Vitrophyric
(C) Porphyritic
(D) Poikilitic

230. The origin of andesitic magmas is most closely associated with which geological process?
(A) Flux melting in subduction zones.
(B) Decompression melting at mid-ocean ridges.
(C) Hotspot activity under continental crust.
(D) Continental rifting.

231. Which of the following is NOT an agent of metamorphism?
(A) Elevated temperature
(B) Directed pressure
(C) Diagenesis
(D) Chemically active fluids

232. What is the defining characteristic of a hornfelsic texture?
(A) Strong foliation and lineation.
(B) Coarse compositional banding.
(C) Fine-grained, granular, and non-foliated appearance.
(D) Large porphyroblasts of garnet and staurolite.

233. A metamorphic rock containing abundant chlorite and epidote, giving it a green color, belongs to the:
(A) Blueschist facies
(B) Greenschist facies
(C) Amphibolite facies
(D) Granulite facies

234. Skarns are rocks formed by metasomatism, typically occurring where:
(A) A granitic intrusion contacts carbonate sedimentary rocks.
(B) Basalt erupts on the sea floor.
(C) A fault zone cuts through shale.
(D) A mudstone is deeply buried.

235. The metamorphism of a mafic rock primarily involves the formation of:
(A) Hornblende and Plagioclase
(B) Quartz and Muscovite
(C) Olivine and Pyroxene
(D) Chlorite and Epidote

236. The term 'magma' encompasses:
(A) Only the liquid melt portion.
(B) The melt, crystals, and dissolved volatiles together.
(C) Only the suspended solid crystals.
(D) Only the dissolved volatile gases.

237. The phenomenon where a single magma body separates into two or more coexisting liquids is known as:
(A) Fractional crystallization
(B) Liquid immiscibility
(C) Assimilation
(D) Filter pressing

238. In the binary system Albite-Anorthite, the relationship between the two end-members is:
(A) Eutectic
(B) Peritectic
(C) Complete solid solution
(D) No solid solution

239. According to the IUGS classification, a volcanic rock is considered 'ultramafic' if its MgO content is >18% and total alkalis are low. Which rock type fits this?
(A) Rhyolite
(B) Komatiite
(C) Basalt
(D) Andesite

240. Match the Textural Terms in List I with their Descriptions in List II.
List I: (Textural Term)
P. Aphanitic
Q. Phaneritic
R. Porphyritic
S. Glassy
List II: (Description)
1. Large crystals in a fine matrix
2. No crystals, non-crystalline
3. Crystals too small to see with naked eye
4. Crystals visible to naked eye
(A) P-3, Q-4, R-1, S-2
(B) P-4, Q-3, R-2, S-1
(C) P-1, Q-2, R-3, S-4
(D) P-3, Q-1, R-4, S-2

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241. Consider the following statements about petrographic provinces:
Statement I : A petrographic province is an area where igneous rocks are related in space, time, and chemical composition.
Statement II : The Deccan Traps of India constitute a major petrographic province.
Statement III: Rocks within a province are described as being consanguineous.
Which of the statements given above are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II and III

242. The process of generating granitic magma by melting pre-existing crustal rocks is called:
(A) Granitization
(B) Anatexis
(C) Fenitization
(D) Diagenesis

243. The presence of 'Spinifex' texture is diagnostic for which type of rock?
(A) Granites
(B) Carbonatites
(C) Komatiites
(D) Andesites

244. Metamorphism that occurs due to the increase in temperature and pressure as rocks are buried deep within the Earth is known as:
(A) Contact metamorphism
(B) Burial metamorphism
(C) Dynamic metamorphism
(D) Shock metamorphism

245. Lineation in a metamorphic rock refers to:
(A) The preferred linear alignment of minerals or structural features.
(B) The segregation of light and dark minerals.
(C) The preferred planar alignment of minerals.
(D) The boundary between different metamorphic zones.

246. In Barrovian-type metamorphism, which mineral typically appears after garnet and before kyanite with increasing grade?
(A) Chlorite
(B) Biotite
(C) Staurolite
(D) Sillimanite

247. Eclogite, a very dense metamorphic rock, is the high-pressure equivalent of what common rock type?
(A) Limestone
(B) Sandstone
(C) Shale
(D) Basalt

248. The two main components of a migmatite are the leucosome and the:
(A) Melanosome
(B) Paleosome
(C) Protolith
(D) Neosome

249. When a granite intrudes into a limestone, the resulting contact metamorphic rock is called a:
(A) Khondalite
(B) Charnockite
(C) Skarn
(D) Mylonite

250. Which pair of rocks is characteristic of the granulite facies terrains of southern India?
(A) Blueschist and Greenschist
(B) Charnockite and Khondalite
(C) Marble and Quartzite
(D) Slate and Phyllite

251. A magma's composition can be changed by all of the following processes EXCEPT:
(A) Assimilation
(B) Magma mixing
(C) Fractional crystallization
(D) Isostatic rebound

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252. The lever rule is used in binary phase diagrams to determine:
(A) The relative proportions of liquid and solid phases present.
(B) The temperature of the system.
(C) The pressure of the system.
(D) The melting point of the components.

253. The reaction Olivine + SiO_2-rich Liquid → Pyroxene is a classic example of a:
(A) Eutectic reaction
(B) Continuous reaction
(C) Peritectic reaction

(D) Solid-state transformation

254. A volcanic rock with a very high proportion of voids, which is light enough to float on water, is called:
(A) Obsidian
(B) Basalt
(C) Pumice
(D) Tuff

255. A large, discordant, batholithic body of granite most likely formed by:
(A) The in-situ metasomatism of pre-existing sedimentary rocks.
(B) The intrusion and slow cooling of granitic magma.
(C) A single, massive, subaerial lava flow.
(D) The high-pressure metamorphism of basalt.

256. What distinguishes ultramafic rocks from mafic rocks?
(A) Ultramafic rocks are volcanic, while mafic rocks are plutonic.
(B) Ultramafic rocks have a higher percentage of ferromagnesian minerals.
(C) Ultramafic rocks have a lower percentage of ferromagnesian minerals.
(D) Ultramafic rocks contain abundant quartz.

257. Which type of metamorphism is primarily associated with meteorite impacts?
(A) Contact metamorphism
(B) Shock metamorphism
(C) Regional metamorphism
(D) Dynamic metamorphism

258. A rock displaying a schistose texture is called a:
(A) Gneiss
(B) Schist
(C) Hornfels
(D) Slate

259. A key difference between metamorphic facies and metamorphic zones is that:
(A) Facies are theoretical P-T fields, while zones are mappable areas.
(B) Facies are based on temperature, zones are based on pressure.
(C) Facies apply to igneous rocks, zones apply to metamorphic rocks.
(D) There is no significant difference.

260. Fenites are metasomatic rocks associated with the emplacement of:
(A) Granites
(B) Basalts
(C) Carbonatites and alkaline complexes
(D) Ophiolites

261. The following question consists of two statements, an Assertion (A) and a Reason (R). Select the correct answer using the codes given below.
Assertion (A) : Assimilation of country rock can significantly alter the composition of a magma.
Reason (R) : For assimilation to occur, the magma must have enough superheat to melt the incorporated rock fragments.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

262. In the IUGS classification of plutonic rocks, what are the four corners of the QAPF diamond?
(A) Quartz, Alkali Feldspar, Plagioclase, Feldspathoid
(B) Quartz, Orthoclase, Plagioclase, Feldspar
(C) Quartz, Amphibole, Pyroxene, Feldspar
(D) Quartz, Albite, Pyroxene, Forsterite

263. Arrange the following rocks in the order they would form during the progressive regional metamorphism of a shale protolith.
1. Gneiss
2. Slate
3. Schist
4. Phyllite

Select the correct chronological order:
(A) 2, 4, 3, 1
(B) 1, 3, 4, 2
(C) 2, 3, 1, 4
(D) 4, 2, 3, 1

264. A batholith is a large, intrusive igneous body with an exposed surface area of:
(A) Less than 10 km^2
(B) Greater than 100 km^2
(C) Between 10 and 50 km^2
(D) Less than 1 km^2

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265. The metamorphism of a limestone containing quartz sand impurities would likely produce calc-silicate minerals such as:
(A) Wollastonite
(B) Staurolite
(C) Glaucophane
(D) Graphite

266. A magma that is rich in $(Na_2O + K_2O)$ relative to SiO_2 and Al_2O_3 is termed:
(A) Peraluminous
(B) Metaluminous
(C) Peralkaline
(D) Subalkaline

267. What is the fundamental control on whether a rock develops a foliated vs. non-foliated texture during metamorphism?
(A) The preferred linear alignment of minerals or structural features.
(B) The presence or absence of significant directed stress.
(C) The temperature of metamorphism.
(D) The chemical composition of the protolith.

268. The concept of metamorphic facies was first developed by:
(A) George Barrow
(B) Pentti Eskola
(C) N. L. Bowen
(D) Alfred Harker

269. The term 'neosome' in a migmatite refers to:
(A) The entire rock.
(B) The newly formed part of the rock.
(C) The part of the rock that has not been melted.
(D) A xenolith within the migmatite.

270. In the Eastern Ghats belt of India, charnockites and khondalites are often found in close association, representing:
(A) A low-grade metamorphic terrain.
(B) An ancient subduction zone complex.
(C) A high-grade granulite facies terrain.
(D) An unmetamorphosed sedimentary basin.

271. Magma becomes more viscous as:
(A) Temperature decreases and silica content increases.
(B) Temperature increases and silica content decreases.
(C) Temperature increases and silica content increases.
(D) Temperature decreases and silica content decreases.

272. In a phase diagram, what does a cotectic line indicate in a ternary system?
(A) A path of constant pressure.
(B) A path along which two solid phases crystallize together.
(C) A boundary of solid solution.
(D) The temperature at which the first solid appears.

273. Which mineral from Bowen's reaction series is most resistant to chemical weathering at the Earth's surface?
(A) Olivine
(B) Pyroxene
(C) Calcium-rich plagioclase
(D) Quartz

274. Spherulitic texture, consisting of radiating fibers of minerals, is formed by:
(A) Very slow cooling in a pluton.
(B) Rapid cooling and devitrification of a glassy rock.
(C) Recrystallization during high-grade metamorphism.
(D) Settling of crystals in a magma chamber.

275. The origin of carbonatites is controversial, but one prominent theory suggests they form by:
(A) Liquid immiscibility from a parental silicate magma.
(B) Complete melting of limestone deposits.
(C) Fractional crystallization of a basaltic magma.
(D) Metasomatism of ultramafic rocks.

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276. Given below are two statements regarding metamorphic textures.
Statement I : Slaty cleavage is a type of foliation.
Statement II : Hornfelsic texture is typically non-foliated.
Which of the above statements is/are correct?
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

277. The zeolite facies represents the ____ conditions of metamorphism.
(A) lowest temperature and pressure
(B) highest temperature and pressure
(C) highest pressure and lowest temperature
(D) highest temperature and lowest pressure

278. Which of the following is NOT a common type of metasomatism?
(A) Fenitization
(B) Greisenization
(C) Silicification
(D) Propanation

279. The metamorphism of mafic rocks to produce eclogite requires:
(A) High pressure and high temperature.
(B) Low pressure and high temperature.
(C) High pressure and relatively low temperature.
(D) Low pressure and low temperature.

280. The protolith for khondalite is interpreted to be:
(A) Basalt
(B) Limestone
(C) An aluminous sedimentary rock
(D) Granite

281. Which process of magma evolution involves the mechanical separation of liquid from crystals?
(A) Magmatic differentiation
(B) Assimilation
(C) Magma mixing
(D) Anatexis

282. The IUGS system classifies igneous rocks primarily based on their:
(A) Color index
(B) Grain size
(C) Mineralogical composition
(D) Tectonic setting

283. What defines the boundary between aphanitic and phaneritic textures?
(A) Whether the rock is volcanic or plutonic.
(B) Whether the majority of crystals are visible to the unaided eye.
(C) The presence or absence of glass.
(D) The percentage of mafic minerals.

284. Match the Metamorphic Facies in List I with their P-T Conditions in List II.
List I: (Metamorphic Facies)
P. Blueschist
Q. Granulite
R. Hornfels
S. Greenschist
List II: (P-T Condition)
1. Low P, High T
2. High P, Low T
3. Low-Medium P, Low-Medium T
4. High P, High T
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-4, R-1, S-3
(C) P-2, Q-1, R-4, S-3
(D) P-3, Q-4, R-1, S-2

285. A layered structure in a migmatite is described as:
(A) Gneissic
(B) Porphyroblastic
(C) Stromatic
(D) Cataclastic

286. What is the plutonic equivalent of an andesite?
(A) Gabbro
(B) Granite
(C) Syenite
(D) Diorite

287. Which agent of metamorphism is dominant in forming rocks of a contact aureole?
(A) Lithostatic pressure
(B) Heat
(C) Directed stress
(D) Fluid pressure

288. A rock that has undergone metamorphism with little or no change in bulk chemical composition is said to be:
(A) Metasomatic
(B) Isochemical
(C) Anatectic
(D) Allochemical

289. Consider the following statements regarding the metamorphism of carbonates:
Statement I : Metamorphism of pure limestone forms marble.
Statement II : Metamorphism of impure, silica-bearing limestone can form calc-silicate

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moved to a cooler environment or erupted at the surface, causing the remaining liquid to crystallize rapidly into smaller grains.

18. (A) The large host crystal crystallized later than the small enclosed crystals
Poikilitic texture is characterized by a large crystal of one mineral, known as an oikocryst, which completely encloses numerous smaller crystals of a different mineral. This spatial relationship indicates that the smaller enclosed crystals formed earlier in the crystallization sequence. The larger host crystal grew later, eventually surrounding the pre-existing smaller grains as it crystallized from the remaining silicate melt.

19. (C) Low-viscosity mafic or ultramafic magma
Layered igneous intrusions typically form from low-viscosity mafic or ultramafic magmas, which allow for efficient crystal settling and convection. As minerals crystallize from the cooling melt, they accumulate at the base of the chamber, creating distinct horizontal layers with varying mineralogical compositions. The low viscosity of basaltic melts is essential for the physical separation and accumulation of these phases.

20. (D) The Bushveld Complex, South Africa
The Bushveld Igneous Complex in South Africa represents the world's largest layered mafic intrusion. It formed through the slow cooling and settling of crystals in a massive magma chamber, resulting in distinct layers of different mineral compositions. This site is globally famous for its vast economic deposits of platinum group elements, chromium, and vanadium, showcasing exceptional rhythmic and cryptic layering.

21. (C) Igneous rocks that are related by a common magmatic origin
A petrographic province is a geographic region where various igneous rocks exhibit similar chemical and mineralogical characteristics, suggesting they share a common parental magma source or tectonic origin. These rocks are often referred to as consanguineous. By studying these provinces, geologists can reconstruct the magmatic evolution and tectonic history of specific areas across different geological time periods.

22. (B) Through extreme metamorphism and metasomatism without a fully molten stage
Granitization is a theory suggesting that granites can form from pre-existing rocks through solid-state transformation. This process involves intense metamorphism and the introduction of chemical components via fluids, known as metasomatism, without the rock ever reaching a fully molten state. While controversial compared to the magmatic origin theory, it was proposed to explain large granite bodies with gradational boundaries.

23. (D) The magmatic origin theory suggests granite forms from the cooling of felsic magma
The magmatic origin theory posits that granite forms from the crystallization of felsic magma, which can be generated by the partial melting of continental crust. This process, known as anatexis, produces a melt that rises and cools slowly at depth, resulting in a coarse-grained rock. This theory is supported by experimental petrology and the observation of sharp intrusive contacts.

24. (A) Both A and R are true and R is the correct explanation of A
Basalt is a fine-grained, dark-colored mafic rock that primarily consists of plagioclase feldspar and pyroxene. Its small crystal size results from the rapid cooling of lava at or very near the Earth's surface, which prevents large crystals from developing. Because basaltic lava has low viscosity, it can flow over large areas before solidifying into the observed volcanic sequences.

25. (C) Basalt
The Deccan Traps in western and central India represent one of the largest volcanic features on Earth. This vast province consists of multiple layers of flood basalts that erupted during the late Cretaceous period. These extensive lava flows were produced by massive fissures, creating a thick sequence of mafic igneous rocks that cover thousands of square kilometers across the Indian subcontinent.

26. (A) Convergent plate margins (subduction zones)
Andesitic magmas are most commonly generated at convergent plate boundaries where an oceanic plate subducts beneath a continental or another oceanic plate. The introduction of water from

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facies conditions.

(C) High-temperature, low-pressure contact settings.

(D) High-pressure, low-temperature subduction zone settings.

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minerals.
Statement III: Carbonate protoliths are very sensitive and produce a wide range of index minerals.
Which of the statements given above are correct?
(A) I and II only
(B) II and III only
(C) I and III only
(D) I, II and III

290. The following question consists of two statements, an Assertion (A) and a Reason (R). Select the correct answer using the codes given below.
Assertion (A) : Migmatites are often found in the highest-grade regions of metamorphic terrains.
Reason (R) : Their formation requires temperatures high enough to begin partially melting the rock.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

291. The separation of an early-formed mineral from the magma, preventing it from reacting with the residual melt, is the key to:
(A) Assimilation
(B) Fractional crystallization
(C) Equilibrium crystallization
(D) Magma mixing

292. The Ab-An-Di system is a ternary diagram used to model the crystallization of:
(A) Granites
(B) Ultramafic rocks
(C) Basalts
(D) Carbonatites

293. The term 'petrographic province' implies that the associated igneous rocks are:
(A) Derived from a common parent magma or magmatic event.
(B) Unrelated in origin but similar in appearance.
(C) All found within a specific national boundary.
(D) Always of the same metamorphic grade.

294. M-type granites, a less common type, are thought to be:
(A) Derived from melting of sedimentary rocks.
(B) Formed by granitization of pelites.
(C) The result of meteorite impacts.
(D) The most fractionated end-product of mantle-derived mafic magmas.

295. Which Indian locality is famous for its carbonatite complex and associated fenitization?
(A) Amba Dongar, Gujarat
(B) Khetri Copper Belt
(C) Kolar Gold Fields
(D) Malanjkhand, Madhya Pradesh

296. Mylonite, a rock found in shear zones, is a product of:
(A) Contact metamorphism
(B) Burial metamorphism
(C) Dynamic metamorphism
(D) Hydrothermal metamorphism

297. What is the correct sequence of aluminosilicate polymorphs with increasing pressure at a moderate temperature?
(A) Andalusite → Sillimanite → Kyanite
(B) Sillimanite → Andalusite → Kyanite
(C) Andalusite → Kyanite → Sillimanite
(D) Kyanite → Andalusite → Sillimanite

298. Agmatite, a type of migmatite structure, consists of:
(A) Well-defined layers of leucosome and melanosome.
(B) Fragments of mafic rock enclosed in a granitic leucosome.
(C) A chaotic, folded mixture of leucosome and melanosome.
(D) A fine-grained, homogeneous appearance.

299. The metamorphism of basic igneous rocks will NOT produce which of the following rocks?
(A) Greenschist
(B) Amphibolite
(C) Eclogite
(D) Marble

300. Charnockites are orthopyroxene-bearing granitic rocks, implying they formed under:
(A) Low-temperature, hydrous conditions.
(B) High-temperature, anhydrous granulite-

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9. (C) A line along which two solid phases crystallize from the melt
A cotectic line in a ternary system represents a boundary between the primary crystallization fields of two different minerals. Along this path, the liquid is in equilibrium with two solid phases that crystallize simultaneously. As the temperature decreases, the composition of the remaining melt moves along this line toward a eutectic or peritectic point where more solid phases eventually appear.

10. (A) Basaltic magmas
The system involving forsterite, fayalite, and silica is fundamental for modeling the crystallization sequences of basaltic magmas. It explains the relationship between olivine and pyroxene during cooling and how the saturation of silica affects mineral stability. This ternary system helps geologists understand the formation of mafic igneous rocks and the evolution of the mantle-derived melts throughout the Earth's crust.

11. (D) The relative proportions of Quartz, Alkali feldspar, Plagioclase, and Feldspathoids
The International Union of Geological Sciences classification system for plutonic rocks relies on the modal mineralogy of the sample. It uses the relative volume percentages of four main components: quartz, alkali feldspar, plagioclase, and feldspathoids. By plotting these proportions on a double-triangular QAPF diagram, petrologists can consistently name coarse-grained igneous rocks based on their actual mineral content and observed textures.

12. (C) I and III only
The International Union of Geological Sciences classification is mineralogical and applies to both plutonic and volcanic rocks using specific diagrams. Rocks containing more than ninety percent mafic minerals are excluded from the standard QAPF double triangle and are classified using separate diagrams based on olivine and pyroxene proportions. This ensures that the classification accurately reflects the distinct mineralogies of ultramafic rocks.

13. (C) The sequential crystallization of minerals from cooling magma
The Reaction Principle, developed by Norman Bowen, explains how minerals form from cooling magma in a specific order. As temperatures drop, earlier-formed minerals react with the remaining melt to produce new minerals. This sequence consists of the continuous series for plagioclase feldspars and the discontinuous series for ferromagnesian minerals, providing a framework for understanding magmatic differentiation and igneous rock diversity.

14. (D) Olivine
Olivine is a high-temperature silicate mineral that is typically the first to crystallize from a cooling basaltic melt. In Bowen's Reaction Series, it sits at the top of the discontinuous branch because it has the highest melting point among the common ferromagnesian silicates. As cooling continues, olivine may react with the liquid to form pyroxene if silica levels are sufficient.

15. (A) Ferromagnesian silicates from olivine to biotite
The discontinuous series in Bowen's model describes how ferromagnesian minerals react with the melt at specific temperatures to form minerals with different crystal structures. The sequence begins with olivine, followed by pyroxene, amphibole, and finally biotite mica. Each step involves a major structural change in the silicate framework, reflecting the decreasing temperature and increasing polymerization of the remaining silicate liquid.

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16. (B) Glassy - Composed entirely of coarse interlocking crystals
A glassy texture occurs when magma cools so rapidly that atoms do not have enough time to arrange themselves into an organized crystalline structure. This results in an amorphous solid without distinct crystals, common in volcanic rocks like obsidian. In contrast, a texture composed entirely of coarse interlocking crystals is described as phaneritic, which typically forms from slow cooling underground.

17. (B) A two-stage cooling history: slow cooling followed by rapid cooling
Porphyritic texture features large, well-formed crystals called phenocrysts embedded in a much finer-grained matrix or groundmass. This indicates a multi-stage cooling history where the magma initially cooled slowly at depth, allowing large crystals to grow. Subsequently, the magma

ANSWERS

1. (B) A mixture of molten rock, suspended crystals, and dissolved gases
Magma is a complex naturally occurring mobile silicate melt found beneath the Earth's surface. It typically consists of a liquid portion called melt, solid crystals of silicate minerals suspended within the liquid, and various dissolved volatiles such as water vapor and carbon dioxide. Once this material reaches the surface and erupts, it is referred to by the term lava.

2. (A) The degree of partial melting of the source rock
The chemical composition of magma depends significantly on the extent to which the parent rock undergoes melting. Low degrees of partial melting often produce magmas enriched in incompatible elements and silica, whereas high degrees result in compositions closer to the bulk source. Other factors include the source rock composition, pressure conditions, and the presence of various volatile components during melting.

3. (A) Both Statement I and Statement II are true
Magmatic differentiation refers to various processes that modify the chemical composition of a magma during its journey through the crust. Fractional crystallization is the most common mechanism, involving the removal of early-formed crystals from the melt. This separation changes the residual liquid's chemistry, allowing a single parent magma to produce a diverse suite of related igneous rocks with different mineralogies.

4. (D) Assimilation
Magmatic assimilation occurs when an ascending body of magma reacts with and incorporates the surrounding host or country rock. The thermal energy of the magma melts or dissolves fragments of the solid wall rock, integrating its chemical components into the melt. This process effectively changes the overall composition of the magma, often making it more silica-rich or felsic during its ascent.

5. (C) Diagenesis
Magmatic differentiation involves physical and chemical changes that diversify magma composition, including crystal settling, liquid immiscibility, and filter pressing. Diagenesis, however, describes the physical and chemical changes occurring in sediments after deposition and during their conversion into sedimentary rock at low temperatures and pressures. Therefore, it is unrelated to the high-temperature processes of igneous mineral crystallization and magma evolution.

6. (B) The boundary separating the all-liquid field from the field of liquid and crystals
Liquidus represents the temperature above which a substance is entirely liquid. In a silica system, this line acts as a phase boundary on a temperature-composition plot, separating the region of complete melt from the area where solid crystals and liquid coexist. Cooling below this line initiates the crystallization process of the first solid phase from the available silicate melt during solidification.

7. (A) P-4, Q-2, R-3, S-1
The eutectic point is the lowest temperature where the entire system can melt, while the peritectic point involves a reaction between a solid and liquid to form a new solid. The liquidus marks the onset of crystallization from a melt, and the solidus signifies the temperature below which the entire material is completely solid. These concepts define phase stability during cooling.

8. (A) Both A and R are true and R is the correct explanation of A
In binary eutectic systems, crystallization typically starts with one mineral, causing the liquid composition to migrate along the liquidus until the eutectic point is reached. At this specific point, both minerals begin to crystallize together at a fixed temperature until all liquid is exhausted. This relationship explains why the temperature remains constant during the final stages of solidification in such systems.

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the subducting slab lowers the melting point of the overlying mantle wedge, producing basaltic melts that evolve into andesite through fractional crystallization and crustal contamination as they rise through the volcanic arc.

27. (D) More than 50% carbonate minerals
Carbonatites are rare and unusual igneous rocks defined by having more than fifty percent carbonate minerals, such as calcite, dolomite, or ankerite. Unlike most igneous rocks which are dominated by silicates, carbonatites are extremely low in silica and often enriched in rare earth elements. They typically occur as small intrusive bodies, dykes, or occasionally as volcanic flows in continental settings.

28. (B) The Amba Dongar complex in Gujarat
The Amba Dongar complex in Gujarat is a well-known Indian occurrence of carbonatite and associated alkaline rocks. This site is significant for its geological diversity and economic deposits, particularly fluorite. The carbonatites here are part of a larger alkaline province and are believed to be related to the Deccan magmatism, providing insights into mantle processes and specialized magmatic evolution.

29. (C) A deficiency in silica relative to alkali components
Alkaline igneous rocks are characterized by high concentrations of sodium and potassium relative to their silica content. This chemical imbalance leads to the formation of silica-undersaturated minerals such as feldspathoids like nepheline or leucite, rather than quartz. These rocks often form in continental rift zones where specialized mantle melting processes occur, producing melts that are enriched in incompatible and alkali elements.

30. (D) Olivine and pyroxene
Ultramafic rocks are characterized by an extremely high proportion of ferromagnesian minerals, typically exceeding ninety percent of the rock's volume. Peridotite and dunite are primary examples, consisting mostly of olivine and pyroxene with very little plagioclase feldspar. These rocks are representative of the Earth's mantle and are often found in the lower portions of layered intrusions or ophiolite sequences.

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31. (A) Temperature
Temperature is considered the most critical agent of metamorphism because it provides the thermal energy necessary to break chemical bonds and drive recrystallization. Heat can be derived from the Earth's internal geothermal gradient or from the proximity of hot igneous intrusions. Increased temperature promotes the formation of new minerals that are stable under higher thermal conditions, transforming the parent rock's mineralogy.

32. (A) Both Statement I and Statement II are true
Pressure and fluids are essential agents of metamorphism that work alongside temperature. Lithostatic pressure acts equally in all directions, while directed pressure causes deformation and foliation. Hydrothermal fluids, rich in dissolved ions, act as catalysts by facilitating the transport of chemical components between minerals. This speeds up reaction rates and can lead to significant changes in the rock's bulk chemical composition.

33. (B) Large-scale mountain building and tectonism at convergent plate boundaries
Regional metamorphism occurs over vast geographic areas and is primarily driven by the intense heat and pressure associated with continental collisions and mountain building. At convergent plate margins, rocks are buried deeply and subjected to directed stress, resulting in the development of foliation and a sequence of index minerals. This process transforms large volumes of crustal rocks into metamorphic varieties.

34. (A) Contact metamorphism
Contact metamorphism happens when rocks are baked by the heat from a nearby igneous intrusion. This process is localized to a zone called a contact aureole surrounding the magma body. Because heat is the dominant agent and pressure is usually low, the resulting rocks are often fine-grained and non-foliated, such as hornfels, reflecting the thermal alteration of the surrounding country rock.

35. (C) Cataclastic or Dynamic metamorphism
Dynamic metamorphism, also known as cataclastic metamorphism, occurs primarily along fault zones where directed pressure and shear stress are dominant. This process

70. (B) Metamorphic differentiation
The segregation of minerals into distinct alternating layers, such as quartz-feldspar-rich and mica-rich bands, is the result of metamorphic differentiation. This process occurs during high-grade metamorphism when chemical components migrate and reorganize to form a banded texture. This mechanism is responsible for the development of gneissic banding, transforming a relatively uniform parent rock into a visually and mineralogically layered metamorphic rock.

71. (B) Schist
Schist is a metamorphic rock characterized by a strong parallel alignment of platy minerals, a texture known as schistosity. This alignment allows the rock to split easily into thin, irregular sheets or flakes. Schists form during regional metamorphism of pelitic or mafic rocks and typically contain visible minerals like mica, chlorite, or hornblende, reflecting medium-grade temperature and pressure conditions during formation.

72. (C) Marking the first appearance of a particular index mineral
An isograd is a line drawn on a geological map that represents the first appearance of a specific index mineral in the field. It marks a boundary of constant metamorphic grade where the temperature and pressure were sufficient for a new mineral to form. By mapping multiple isograds, such as the garnet or kyanite isograds, geologists can visualize the spatial progression of metamorphism.

73. (C) Medium to high temperature and medium pressure
The amphibolite facies represents medium to high-grade metamorphic conditions, typically involving temperatures between five hundred and seven hundred degrees Celsius and moderate pressures. It is a common facies in regional metamorphic belts and is characterized by mineral assemblages containing hornblende and plagioclase in mafic rocks. These conditions reflect deep burial and significant heating during tectonic mountain-building events in the crust.

74. (C) Carbonatites and alkaline rocks
Fenitization is a specific type of metasomatism that occurs in the country rocks surrounding alkaline or carbonatite intrusions. It involves the introduction of alkalis, particularly sodium and potassium, from the magmatic fluids into the wall rock. This process transforms the original minerals into new alkaline varieties like alkali amphiboles and pyroxenes, creating a distinct halo of altered rock around the intrusion.

75. (A) 1, 2, 4, 3
In a binary eutectic system, crystallization begins when the liquid cools to the liquidus temperature. As the first mineral forms, the composition of the remaining liquid changes, following the liquidus line. Eventually, the melt reaches the eutectic composition, where both minerals begin to crystallize simultaneously at a constant temperature until the entire liquid is exhausted and the system is solid.

76. (B) Melanosome or Restite
In a migmatite, the melanosome, also referred to as restite, is the dark-colored portion of the rock. It represents the residual solid material that remained after the light-colored granitic melt, or leucosome, was extracted during partial melting. The melanosome is typically enriched in refractory mafic minerals like biotite, hornblende, or garnet, which have higher melting points than the felsic components.

77. (B) Talc or Tremolite
The metamorphism of an impure, clay-rich dolomite involves complex chemical reactions between carbonate minerals and silica from the clay. At low to medium metamorphic grades, these reactions often produce magnesium-rich silicate minerals such as talc or tremolite. The specific mineral that forms depends on the available temperature, pressure, and the concentration of volatile fluids like water and carbon dioxide during the process.

78. (B) An increase in temperature at a certain pressure
Kyanite and sillimanite are polymorphs of aluminum silicate that are stable under different conditions. The transition from kyanite to sillimanite typically occurs as temperature increases while pressure remains relatively

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tectonic environment where the metamorphism originally occurred.

44. (B) Blueschist facies
Blueschist facies metamorphism occurs under conditions of high pressure and relatively low temperature. This specific environment is typically found in subduction zones where oceanic crust is rapidly forced deep into the mantle. The presence of blue-colored minerals like glaucophane indicates these unique conditions, reflecting the tectonic processes associated with convergent plate boundaries where cold lithospheric slabs descend into the Earth.

45. (C) Significant change in bulk chemical composition due to fluid interaction
Metasomatism is a metamorphic process that involves the chemical alteration of a rock through the introduction or removal of components by hydrothermal fluids. Unlike isochemical metamorphism, metasomatism significantly changes the rock's bulk chemical composition. This often occurs near igneous intrusions where hot, ion-rich fluids circulate through fractures, reacting with the country rock to form new minerals and specialized ore deposits.

46. (D) Foliation
Fenitization, greisenization, and skarn formation are all specific types of metasomatism involving significant chemical changes driven by fluids. Foliation, however, is a physical metamorphic texture characterized by the parallel alignment of minerals due to directed pressure. While foliation describes the structural arrangement of grains within a rock, it does not refer to the chemical replacement processes that define metasomatism.

47. (A) Metamorphic and igneous (or igneous-like) rocks
A migmatite is a complex rock that forms under extreme high-grade metamorphic conditions where partial melting begins. It exhibits a mixture of metamorphic textures from the solid residual rock and igneous-looking textures from the solidified melt. These rocks represent the boundary between high-grade metamorphism and the generation of magma, showing how crustal rocks transition into a partially molten state.

48. (B) Leucosome
In a migmatite, the leucosome is the light-colored, granitic portion that represents the solidified partial melt. It typically consists of quartz and feldspar, which have the lowest melting temperatures and are the first to liquefy during high-grade metamorphism. The leucosome often forms distinct veins or patches within the darker, residual part of the rock, reflecting the segregation of the liquid phase.

49. (C) Marble
The metamorphism of pure limestone, which is composed primarily of the mineral calcite, results in the formation of marble. During this process, the calcite crystals recrystallize into a larger, interlocking granoblastic mosaic. Because pure limestone lacks the necessary chemical variety to form a wide range of new minerals, the resulting marble remains non-foliated and predominantly composed of calcium carbonate.

50. (C) Pelites (shales and mudstones)
George Barrow originally defined the sequence of metamorphic zones based on his studies of pelitic rocks, which are metamorphosed shales and mudstones. Pelites are chemically diverse and sensitive to changes in temperature and pressure, allowing for the formation of a wide variety of index minerals like garnet, kyanite, and sillimanite. This sensitivity makes them ideal for tracking progressive metamorphic changes.

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51. (A) P-3, Q-2, R-1, S-4
Marble forms from limestone, while quartzite is the metamorphosed equivalent of sandstone. Slate originates from the low-grade metamorphism of shale, and greenstone is a product of metamorphosed basalt. Each metamorphic rock retains chemical characteristics from its original parent rock, or protolith, which determines the potential mineral assemblages that can form during the transformation under increased heat and pressure.

52. (C) Orthopyroxene (hypersthene) in a granitic-composition rock
Charnockites are a specific group of high-grade metamorphic rocks that resemble granites in composition but contain the mineral orthopyroxene, specifically hypersthene. They are characteristic of granulite facies terrains,

surface decreases as the melt composition evolves. The lowest possible temperature at which a liquid can exist in equilibrium with solid phases is at the ternary eutectic point. At this point, all three solid components begin to crystallize simultaneously from the melt at a constant temperature until solidification is complete.

106. (C) Dunite
Dunite is an ultramafic plutonic rock that consists of at least ninety percent olivine. It is essentially the end-member of the peridotite group. Dunite typically forms as a cumulate in the lower portions of large layered mafic intrusions or is found as fragments of the upper mantle brought to the surface during tectonic processes, representing a very magnesium-rich and silica-poor composition.

107. (B) Hydrothermal metamorphism
Hydrothermal metamorphism is the dominant type occurring at mid-ocean ridges. As seawater circulates through the fractured oceanic crust near the spreading center, it is heated by the underlying magma. The hot, chemically active water reacts with the basaltic rocks, causing significant mineralogical changes and metal transport. This process is responsible for the formation of serpentinites and the specialized mineral deposits found at hydrothermal vents.

108. (C) Hornfelsic - Fine-grained, non-foliated, equigranular
Hornfelsic texture is a characteristic feature of contact metamorphic rocks. It consists of a fine-grained, equigranular mosaic of minerals that lack any preferred orientation or foliation. This texture develops when heat is the primary driver of change and there is no significant directed pressure to align the grains. Such rocks typically form in the bake zones, or aureoles, surrounding igneous intrusions.

109. (C) Metabasite or Amphibolite
The metamorphism of a basalt protolith, which is a mafic igneous rock, produces a variety of rocks depending on the grade. At medium to high temperatures and pressures, it typically results in an amphibolite, characterized by hornblende and plagioclase. Collectively, these metamorphosed mafic rocks are called metabasites. The mineralogy of these rocks is a reliable indicator of the intensity of the metamorphic conditions.

110. (C) The unaffected or less-affected protolith material
In the context of migmatites, the paleosome refers to the part of the rock that has remained largely unaffected by the partial melting process. It represents the original parent rock, or protolith, and typically retains its metamorphic fabric and mineralogy. The paleosome contrasts with the neosome, which includes the newly formed melt-derived leucosome and the dark, residual melanosome created during high-grade metamorphism.

111. (A) Separation of crystals from a liquid melt to form a different residual melt
Magmatic differentiation is the general process by which a single parent magma evolves into diverse daughter magmas with different compositions. The most common mechanism is fractional crystallization, where crystals that form early are physically separated from the remaining liquid. Because these crystals remove specific elements, the chemistry of the residual melt changes, allowing for the formation of a wide range of igneous rocks.

112. (B) Silica-undersaturated
The presence of feldspathoids like leucite or nepheline in an igneous rock indicates that the parent magma was silica-undersaturated. These minerals only form when there is not enough silica available in the melt to create common feldspars like orthoclase or albite. Consequently, such rocks never contain primary quartz, as any excess silica would have reacted with the feldspathoids to form stable feldspar minerals.

113. (C) Dolerite or Diabase
Ophitic texture is a characteristic feature of dolerite, also known as diabase. In this texture, laths of plagioclase feldspar are partially or completely enclosed by larger, interlocking crystals of pyroxene, typically augite. This relationship suggests that plagioclase began to crystallize slightly before or simultaneously with the pyroxene. This texture is common in medium-grained mafic rocks found in dykes and sills.

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from crustal melts and granitization via solid-state metasomatism. S-type granites are a specific category derived from the partial melting of sedimentary source rocks, often characterized by high aluminum content. Together, these concepts illustrate the diverse geological processes, ranging from magmatic intrusion to extreme metamorphism, that can produce granitic rocks.

62. (C) Gabbro
Gabbro is the plutonic, or coarse-grained, equivalent of basalt. Both rocks share a similar mafic chemical composition, being rich in magnesium and iron and poor in silica. While basalt forms from the rapid cooling of lava at the Earth's surface, gabbro forms from the slow cooling of magma deep underground, allowing large crystals of plagioclase and pyroxene to develop.

63. (B) Subaqueous (underwater) eruption
Pillow lavas are distinctive rounded structures that form when basaltic lava is erupted underwater. The rapid quenching of the hot lava by cold water creates a glassy skin, while the internal pressure causes the lava to bulge out into pillow-like shapes. The presence of these structures in ancient rock sequences is a definitive indicator of a submarine or subaqueous volcanic environment.

64. (C) Volcanic arcs on continental margins
Andesite is a volcanic rock of intermediate composition that is characteristic of volcanic arcs at convergent plate boundaries. Its name comes from the Andes Mountains, where it is exceptionally common due to the subduction of oceanic crust beneath the South American continent. These rocks form through a combination of mantle melting, fractional crystallization, and the assimilation of continental crust by rising magmas.

65. (A) Both A and R are true and R is the correct explanation of A
Alkaline rocks are frequently found in continental rift zones where the crust is being pulled apart. This tectonic setting facilitates low degrees of partial melting at great depths in the mantle. Because incompatible elements and alkalis like sodium and potassium concentrate in the first-formed melts, the resulting magmas are silica-undersaturated and enriched in these components, leading to the formation of alkaline suites.

66. (B) Spinifex
Komatiites are rare, high-magnesium ultramafic volcanic rocks that are primarily found in Archean greenstone belts. They are famous for their unique spinifex texture, which consists of long, bladed crystals of olivine or pyroxene. This texture is thought to form by the rapid quenching of extremely hot, low-viscosity lava, reflecting the much higher mantle temperatures that existed early in Earth's history.

67. (C) Pressure
Pressure is a fundamental physical agent of metamorphism that increases with depth in the Earth's crust. It can be uniform lithostatic pressure, which reduces volume, or directed stress, which causes deformation and the development of foliation. Unlike chemical agents like water or carbon dioxide, pressure is a mechanical force that influences mineral stability and the structural fabric of the resulting metamorphic rocks.

68. (B) Contact
Contact metamorphism is the primary process occurring within contact aureoles surrounding igneous intrusions. The intense heat from the magma body bakes the adjacent country rock, leading to recrystallization and the formation of new minerals. Because this process is driven mainly by temperature at relatively shallow depths, the resulting rocks are typically non-foliated and their mineralogy is controlled by the local thermal gradient.

69. (C) Cataclastic
Cataclastic texture is characteristic of dynamic metamorphism, which occurs in high-stress environments such as fault zones. This texture is produced by the mechanical fragmentation, crushing, and grinding of rocks as they slide past each other. The resulting material consists of angular fragments embedded in a finer matrix of pulverized rock, providing clear evidence of intense brittle deformation and tectonic movement.

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grained groundmass and often exhibits ophitic textures. Because basalt is silica-poor, it does not contain abundant quartz or muscovite, which are minerals characteristic of felsic rocks like granite. The absence of these minerals is a key identifying feature of basaltic compositions.

88. (B) It requires large-scale transfer of materials
Granitization is a controversial hypothesis because it requires the massive migration and exchange of chemical elements through solid rock over large distances. To transform a sedimentary rock into granite without melting, vast amounts of sodium, potassium, and silica must be introduced by fluids while other elements are removed. Many geologists find the mechanical and chemical requirements for such large-scale metasomatism difficult to explain.

89. (B) P-4, Q-1, R-3, S-2
Anorthosite is dominated by plagioclase feldspar, while dunite is composed almost entirely of olivine. Syenite is characterized by a high proportion of alkali feldspar, and carbonatite is defined by its high content of carbonate minerals like calcite and dolomite. These dominant minerals are the primary basis for identifying and naming these distinct igneous rock types in both hand samples and thin sections.

90. (B) Tectonically active fluids
The primary agents of metamorphism are heat, pressure, and chemically active fluids. While heat and pressure provide the physical energy for change, fluids act as essential chemical agents. These hydrothermal fluids, often rich in water and dissolved ions, facilitate the transport of atoms between minerals, significantly accelerating reaction rates and enabling the formation of new mineral phases that would otherwise be sluggish.

91. (B) 'Kinds' refer to geological settings; 'types' refer to P-T changes
In metamorphic petrology, 'kinds' of metamorphism usually describe the specific geological or tectonic setting, such as contact, regional, or dynamic metamorphism. In contrast, 'types' of metamorphism often refer to the specific changes in pressure and temperature conditions, such as high-pressure/low-temperature or prograde versus retrograde metamorphism. This distinction helps geologists categorize both the environmental context and the physical drivers of the transformation.

92. (C) Marble or Quartzite, which are monomineralic
Granoblastic texture consists of equigranular, often anhedral crystals that form an interlocking mosaic. This texture is typical of non-foliated metamorphic rocks, particularly those that are monomineralic like marble or quartzite. During recrystallization, the minerals grow in all directions at similar rates because there is no significant directed stress to cause the alignment or segregation of the grains into layers.

93. (B) Pelites, because their chemistry allows many minerals
The index mineral concept works best in pelitic rocks, which are derived from shales and mudstones. These rocks are rich in aluminum, silica, iron, and magnesium, a diverse chemistry that allows for the formation of many different metamorphic minerals as temperature and pressure increase. This variety enables geologists to define a clear sequence of zones, such as chlorite, biotite, and garnet zones.

94. (C) Granulite facies
The granulite facies represents the highest temperature conditions of regional metamorphism in the continental crust. It occurs deep within the Earth where temperatures exceed seven hundred degrees Celsius. Under these anhydrous conditions, hydrous minerals like mica and amphibole become unstable and are replaced by anhydrous minerals like pyroxene. This facies is characteristic of the deep roots of ancient mountain belts.

95. (C) Retrograde metamorphism
Retrograde metamorphism is the process where a high-grade metamorphic mineral assemblage reacts to form minerals stable at lower temperatures and pressures. This typically occurs as a rock is uplifted and cools toward the surface. However, retrograde reactions are often incomplete because they usually require the re-introduction of fluids, like water, that were driven off during the earlier prograde heating stage.

96. (B) Carbonate rocks like limestone or dolostone
Skarns are metasomatic rocks that form when magma intrudes into carbonate-rich sedimentary

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constant or also increases. Finding both minerals together suggests the rock experienced the specific boundary conditions between their stability fields, providing a critical data point for reconstructing the pressure-temperature path of the metamorphism.

79. (C) Granulite facies metamorphism
The charnockite series of southern India is a world-renowned example of granulite facies metamorphism. These rocks formed under extremely high temperatures and anhydrous conditions in the deep continental crust. The presence of orthopyroxene in these granitic-composition rocks is a definitive indicator of the granulite facies, reflecting the dehydration and recrystallization of the crust during ancient, large-scale tectonic and thermal events.

80. (B) Garnet, Sillimanite, and Graphite
Khondalite is characterized by a specific mineralogical assemblage that typically includes garnet, sillimanite, quartz, and often graphite. These minerals reflect the high-grade metamorphism of an aluminum-rich sedimentary protolith. The presence of sillimanite and garnet indicates that the rock reached granulite facies conditions. Khondalites are iconic rocks of the Eastern Ghats mobile belt, representing deeply buried and metamorphosed ancient sedimentary basins.

81. (C) The thermal energy available for melting
Magma assimilation is primarily limited by the amount of thermal energy, or heat, available within the magma body. To incorporate country rock, the magma must provide enough heat to raise the temperature of the solid fragments to their melting point and supply the latent heat of fusion. As assimilation proceeds, the magma cools and eventually loses the ability to melt additional material.

82. (C) Complete solid solution
The binary system for forsterite and fayalite, which are the magnesium and iron end-members of the olivine group, exhibits complete solid solution. This means that magnesium and iron ions can freely substitute for each other in the crystal lattice across all compositions. On a phase diagram, this relationship is shown by a continuous loop between the liquidus and solidus without any eutectic point.

83. (D) It classifies rocks based on their color index
The IUGS QAPF diagram is a mineralogical classification system based on the relative proportions of quartz, alkali feldspar, plagioclase, and feldspathoids. While the color index, representing the percentage of mafic minerals, is used to describe rocks, it is not the primary basis for plotting on the QAPF diagram. Separate classification schemes are used for rocks that are predominantly mafic or ultramafic.

84. (A) Bowen's Reaction Principle
A reaction rim texture provides direct microscopic evidence of Bowen's Reaction Principle. It forms when an early-crystallized mineral becomes unstable as the magma cools and begins to react with the surrounding liquid. This reaction creates a rim of a new, lower-temperature mineral around the original crystal. For example, a rim of pyroxene often surrounds an olivine crystal that has reacted with the melt.

85. (B) The rapid escape of dissolved gas bubbles
Vesicular texture is characterized by numerous small holes or cavities, called vesicles, in a volcanic rock. These form when dissolved gases, such as water vapor and carbon dioxide, rapidly expand and escape from the magma as it nears the surface and erupts. If the lava solidifies quickly enough, the empty spaces left by the gas bubbles are preserved, creating rocks like scoria or pumice.

86. (C) Bimodal (felsic and mafic) anorogenic magmatic province
The Malani Igneous Suite in Rajasthan is a prominent example of a bimodal anorogenic magmatic province. It consists of large volumes of felsic rocks, like rhyolite and granite, alongside smaller amounts of mafic rocks, such as basalt and dolerite. This suite formed in a non-orogenic setting, possibly related to crustal extension or plume activity, rather than active mountain-building processes at plate boundaries.

87. (C) Abundant quartz and muscovite
Basalt is a mafic igneous rock typically composed of pyroxene, calcium-rich plagioclase, and sometimes olivine. It is characterized by a fine-

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involves the mechanical crushing, grinding, and pulverization of rocks without significant chemical or mineralogical changes. The resulting rocks, such as fault breccia or mylonite, exhibit distinctive textures that reflect the intense deformation and movement along the structural boundary.

36. (D) A homogeneous parent rock develops mineralogical bands during metamorphism
Metamorphic differentiation is a process where a relatively homogeneous parent rock becomes chemically or mineralogically segregated into distinct bands. This typically occurs under high-grade conditions where minerals like quartz and feldspar migrate to form light-colored layers, while mafic minerals like biotite and hornblende concentrate into dark layers. This mechanism contributes to the development of gneissic banding in high-grade metamorphic rocks.

37. (C) The segregation of minerals into light and dark bands
Gneissic texture is a high-grade metamorphic feature characterized by the segregation of minerals into alternating light and dark bands. The light-colored bands are typically composed of quartz and feldspar, while the dark bands consist of ferromagnesian minerals like biotite or hornblende. This banding results from intense heat and pressure, which allow for the chemical migration and reorganization of minerals during metamorphism.

38. (B) Schistose
Schistose texture is a prominent example of foliation in metamorphic rocks, characterized by the parallel alignment of large, platy minerals like mica. This texture develops under regional metamorphic conditions where directed pressure forces the minerals to grow perpendicular to the stress direction. The resulting rock, known as schist, exhibits a visible sheen and easily splits into thin, irregular flakes or layers.

39. (D) Characterized by a specific index mineral or mineral assemblage
A metamorphic zone is a region on the Earth's surface where rocks exhibit a similar degree of metamorphism, defined by the first appearance of a specific index mineral. For example, in pelitic rocks, zones are named after minerals like chlorite, garnet, or sillimanite. These zones help geologists map the spatial variations in temperature and pressure that affected the crust during metamorphism.

40. (A) Chlorite
In the progressive metamorphism of pelitic rocks, chlorite is the first index mineral to appear, marking the lowest grade of metamorphism. As temperature and pressure increase, chlorite reacts to form other minerals like biotite and garnet. The sequence of index minerals, known as Barrovian zones, provides a reliable method for determining the peak metamorphic conditions experienced by the sedimentary protolith.

41. (C) The intensity of metamorphism related to temperature and pressure
Metamorphic grade describes the overall intensity of the metamorphic process, reflecting the maximum temperature and pressure conditions the rock reached. Low-grade metamorphism occurs at relatively low temperatures and pressures, while high-grade metamorphism involves extreme conditions near the melting point of rocks. The mineral assemblage and texture of a metamorphic rock are direct consequences of its specific metamorphic grade and history.

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42. (A) Slate, Phyllite, Schist, Gneiss
The sequence from slate to gneiss represents the progressive metamorphism of a shale protolith under increasing temperature and pressure. Slate is low-grade and fine-grained, while phyllite shows a slight increase in grain size and sheen. Schist features visible platy minerals, and gneiss represents the highest grade with distinct mineral banding. This progression reflects the continuous growth and reorganization of minerals.

43. (D) A set of mineral assemblages forming under specific P-T conditions
Metamorphic facies is a conceptual framework that groups together mineral assemblages that form under the same range of pressure and temperature conditions. Regardless of the protolith's composition, rocks within a facies will develop specific minerals that are stable at those conditions. This concept, developed by Pentti Eskola, allows geologists to reconstruct the

rocks like limestone or dolostone. Hot, ion-rich fluids from the cooling magma react with the calcium or magnesium in the carbonate rock, producing a variety of calc-silicate minerals such as garnet and pyroxene. This contact metasomatism often results in complex mineralogies and can host important economic metal deposits.

97. (B) High-grade metamorphism and magmatism
Migmatites are composite rocks that represent the transition between high-grade metamorphism and the beginning of magmatic processes. They form at extreme temperatures where rocks undergo partial melting, or anatexis. The resulting rock contains both a metamorphic residual part and an igneous-looking part crystallized from the melt. Migmatites provide direct evidence of how the continental crust begins to melt and generate new magmas.

98. (C) Greenschist or Greenstone
When mafic rocks like basalt undergo metamorphism under greenschist facies conditions, they are transformed into greenschist or greenstone. These rocks are characterized by an abundance of green minerals such as chlorite, actinolite, and epidote, which give the rock its distinctive color. This low-to-medium grade metamorphism is common in ancient volcanic sequences and indicates temperatures between three hundred and four hundred fifty degrees.

99. (A) A pyroxene-bearing granite
Charnockite is frequently described as a pyroxene-bearing granite because it has a felsic, granitic composition but contains the mineral orthopyroxene, which is usually found in mafic rocks. This unusual mineralogy is a hallmark of granulite facies metamorphism, indicating that the rock formed at great depth under very high temperatures and exceptionally dry, or anhydrous, conditions within the continental crust.

100. (A) Both Statement I and Statement II are true
Khondalites are high-grade metamorphic rocks that are characteristic of granulite-facies terrains. They are interpreted as metamorphosed aluminous sediments, reflecting an origin as ancient shales or mudstones that were deeply buried and subjected to extreme heat and pressure. Their mineralogy, which typically includes garnet and sillimanite, confirms their status as products of intense prograde metamorphism within the Earth's deep crust.

101. (B) 2, 4, 1, 3
In the discontinuous reaction series of Bowen's model, minerals crystallize in a specific order as magma cools. Olivine forms first at the highest temperatures, followed by pyroxene, then amphibole, and finally biotite mica at lower temperatures. Each mineral in this sequence has a different crystal structure, reflecting the increasing complexity of the silicate framework as the remaining melt becomes more polymerized.

102. (A) Both A and R are true and R is the correct explanation of A
The texture of an igneous rock is a direct reflection of its cooling rate and environment. Slow cooling deep within the crust provides ample time for atoms to migrate and form large, visible crystals, resulting in a phaneritic texture. In contrast, rapid cooling at the surface restricts crystal growth, leading to fine-grained aphanitic or even glassy textures without any visible crystals.

103. (D) The rate of weathering of the overlying rock
The composition of primary magma is determined by internal factors such as the chemical makeup of the source rock, the temperature and pressure during partial melting, and the presence of volatiles like water. Weathering is a surface process that breaks down rocks after they have formed and been exposed. Therefore, the rate of weathering has no influence on the initial generation of magma at depth.

104. (B) II and III only
A metamorphic facies is defined by a set of mineral assemblages, not a single mineral. All rocks within a facies have experienced the same range of pressure and temperature conditions, but their specific mineralogy depends on the composition of the original protolith. For example, a basalt and a shale will develop very different minerals even if they are metamorphosed within the same facies.

105. (B) Ab-Di-An ternary eutectic
In the ternary system involving albite, anorthite, and diopside, the temperature of the liquidus

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representing the deep continental crust that has undergone metamorphism under extremely high temperatures and anhydrous conditions. These rocks are particularly abundant in the ancient shield areas of southern India and other continents.

53. (C) Alumina-rich sediments (pelites)
Khondalites are high-grade metamorphic rocks commonly found in the Eastern Ghats of India. They are interpreted as metamorphosed aluminous sediments, specifically pelites, that have undergone granulite facies conditions. Their characteristic mineral assemblage includes garnet, sillimanite, quartz, and graphite. These rocks provide vital evidence regarding the tectonic and thermal history of the ancient Precambrian crustal blocks during major mountain-building events.

54. (C) All magma originates from the complete melting of the Earth's outer core
Magma is primarily generated in the upper mantle and crust through processes like decompression melting, flux melting, and heat transfer. The Earth's outer core is a liquid iron-nickel alloy and does not serve as the source for silicate magmas that form igneous rocks. Most magmatism occurs at plate boundaries or hotspots where specific conditions allow the partial melting of rocks.

55. (B) A melting range where both liquid and solid can coexist
In a binary system with a solid solution, such as the albite-anorthite series, there is no single melting point. Instead, there is a temperature range between the liquidus and solidus lines where liquid and solid phases coexist in equilibrium. As the temperature changes within this range, the compositions of both the melt and the crystals continuously evolve through chemical exchange.

56. (A) Both Statement I and Statement II are true
At the peritectic point in a binary system, the temperature remains constant as a solid phase reacts with the liquid to form a new solid phase. Similarly, in the forsterite-fayalite-silica system, early-formed olivine can react with a silica-rich melt to produce pyroxene. These reactions are fundamental to understanding the phase relationships and crystallization sequences in cooling magmas as they evolve.

57. (B) Olivine, Orthopyroxene, and Clinopyroxene
The IUGS classification for ultramafic rocks, which contain more than ninety percent mafic minerals, is based on the relative proportions of olivine, orthopyroxene, and clinopyroxene. These proportions are plotted on a specialized triangular diagram to define rock types like dunite, harzburgite, and lherzolite. This mineralogical approach ensures a consistent nomenclature for rocks that form the bulk of the Earth's upper mantle.

58. (C) Plagioclase Feldspars
The continuous reaction series in Bowen's model describes the evolution of plagioclase feldspar as magma cools. It begins with calcium-rich anorthite at high temperatures and progresses to sodium-rich albite at lower temperatures. Throughout this process, the crystal structure of the feldspar remains the same, while the ratio of calcium to sodium within the lattice changes continuously through ion exchange with the melt.

59. (C) Porphyritic
A rock with large crystals, such as amphibole, surrounded by a finer-grained matrix exhibits a porphyritic texture. The large crystals are phenocrysts, which formed during an initial period of slow cooling, while the surrounding matrix, or groundmass, represents a subsequent stage of more rapid crystallization. This texture is common in volcanic and shallow intrusive rocks and provides evidence of a complex cooling history.

60. (C) Crystal settling and fractional crystallization from a convecting magma chamber
Rhythmic layering in large mafic intrusions like Skaergaard is primarily caused by the repeated settling of crystals from a cooling magma. As minerals crystallize, they sink to the floor of the chamber, often aided by magmatic currents and convection. This process creates alternating layers of different minerals, reflecting fluctuating conditions or repeating cycles of crystallization and accumulation within the evolving magma body.

61. (D) I, II and III
The origin of granite is explained by various theories, including magmatic crystallization

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114. (B) Large Igneous Province (LIP)
A Large Igneous Province is a vast region characterized by enormous volumes of mafic igneous rocks erupted or intruded over a short geological time span. Classic features include massive flood basalt sequences, extensive radiating dyke swarms, and a relationship to mantle plumes. Examples like the Deccan Traps or the Siberian Traps showcase the scale and volcanic intensity associated with these major crustal events.

115. (C) In-situ replacement of sedimentary rocks by metasomatic fluids
The magmatic origin of granite is supported by processes like the fractional crystallization of basaltic melts, partial melting of the crust known as anatexis, and magma mixing. In-situ replacement of solid sedimentary rocks by fluids without melting is the core principle of the granitization theory, which is the historical alternative to the magmatic origin. Most modern evidence supports magmatic processes for large granite bodies.

116. (B) Zoned plagioclase phenocrysts in a fine-grained groundmass
Andesites frequently exhibit a porphyritic texture with prominent phenocrysts of plagioclase feldspar. These crystals often show compositional zoning, reflecting changes in the magma's chemistry and temperature as they grew. This texture, combined with a fine-grained groundmass of plagioclase and pyroxene, is a diagnostic petrographic feature. It records the complex evolution of magmas within the volcanic systems typical of convergent plate boundaries.

117. (C) Peridotite
Peridotite is a classic example of an ultramafic rock, meaning it consists of more than ninety percent ferromagnesian minerals. It is primarily composed of olivine and pyroxene and contains very little silica or feldspar. Peridotite is the dominant rock type of the Earth's upper mantle and is only brought to the surface through tectonic processes or as xenoliths within certain types of volcanic eruptions.

118. (B) P-3, Q-4, R-1, S-2
Each metamorphic facies is defined by a characteristic mineral assemblage. Blueschist features glaucophane and lawsonite, while eclogite is defined by omphacite pyroxene and garnet. Greenschist is identified by chlorite, albite, and epidote. Granulite facies rocks contain orthopyroxene, clinopyroxene, and plagioclase. These minerals serve as critical indicators of the specific temperature and pressure conditions the rock experienced during its metamorphic history.

119. (B) Reactions are slow and require fluids driven off during prograde stages
Retrograde metamorphism occurs during cooling and uplift, but it is often incomplete. This is primarily because the chemical reactions required to form lower-grade minerals are very slow at lower temperatures. Furthermore, the fluids, such as water, that are needed for these reactions were often expelled from the rock during the earlier prograde heating stage. Without re-introduced fluids, the high-grade minerals remain preserved.

120. (B) Kyanite
Kyanite is an aluminum silicate polymorph that is a key indicator of high-pressure conditions in metamorphosed pelitic rocks. While andalusite forms at low pressure and sillimanite at high temperature, kyanite is stable at the relatively high pressures typical of deep burial in regional metamorphic belts. Its presence helps geologists identify the pressure-temperature path and tectonic setting of the metamorphosed sequence.

121. (B) Magma is molten rock below the surface; lava is on the surface
The fundamental difference between magma and lava is their location relative to the Earth's surface. Magma is the term used for molten rock, including dissolved gases and suspended crystals, while it remains underground. Once this molten material reaches the surface through a volcanic vent or fissure, it is called lava. This change in environment also significantly affects the cooling rate and resulting texture.

122. (A) Early-formed, denser crystals sink through the less dense liquid magma
Crystal settling is a physical mechanism of magmatic differentiation. As minerals like olivine or chromite crystallize from a cooling magma, they are often denser than the remaining liquid melt. Under the influence of gravity,

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composition is cooled, it solidifies into two or more solid phases simultaneously at a constant temperature. This behavior is similar to that of a pure substance, even though it involves multiple chemical components and mineral phases.

158. (D) Olivine
Feldspathoids are a group of anhydrous silicate minerals, such as nepheline, leucite, and sodalite, that are chemically similar to feldspars but contain less silica. They are used in the IUGS classification to identify silica-undersaturated rocks. Olivine, while an important mafic mineral, is an orthosilicate and is not part of the feldspathoid group. Its presence is classified separately in specialized ultramafic or mafic diagrams.

159. (A) Both Statement I and Statement II are true
Bowen's reaction series consists of two distinct branches. The discontinuous series involves a sequence of ferromagnesian minerals, such as olivine and pyroxene, each having a completely different crystal structure. The continuous series involves plagioclase feldspars, which maintain the same crystal structure while their chemical composition changes smoothly from calcium-rich to sodium-rich as the magma cools and reacts with the surrounding silicate melt.

160. (B) Cooling was so rapid that no time for crystal formation occurred
A glassy texture indicates that the magma cooled extremely quickly, a process known as quenching. This rapid drop in temperature prevents the atoms from moving and organizing into the regular, repeating patterns that define mineral crystals. Instead, the atoms are frozen" in a disordered, amorphous state. This is common in volcanic eruptions where lava is ejected into the air or flows into cold water.

161. (B) Its primary mineralogy contains more than 50% carbonate minerals
The distinguishing feature of a carbonatite is its chemical and mineralogical composition, which is dominated by carbonate minerals like calcite, dolomite, or ankerite. While most igneous rocks are silicate-based, carbonatites contain more than fifty percent carbonate minerals by volume. They are rare igneous rocks, typically associated with continental rifting, and are important sources of rare earth elements, niobium, and other specialized industrial minerals.

162. (C) Foliation
Directed pressure, also known as differential stress, is a primary agent of metamorphism that causes minerals to grow or rotate into a preferred parallel orientation. This result is known as foliation. Foliation allows the rock to split along specific planes and is characteristic of rocks formed during regional metamorphism, such as slate, schist, and gneiss. It provides clear evidence of the tectonic forces acting on the crust.

163. (A) A zone of altered rock surrounding an igneous intrusion
A contact aureole is the region of country rock surrounding an igneous intrusion that has been mineralogically and physically altered by the heat of the magma. Within this zone, contact metamorphism occurs, creating a gradient of metamorphic intensity that decreases with distance from the intrusion. The width and mineralogy of the aureole depend on the size and temperature of the magma body and the host rock composition.

164. (C) Pure quartz sandstone
The protolith of quartzite is a sandstone composed almost entirely of quartz grains. During metamorphism, the quartz grains recrystallize and fuse together into a dense, hard mosaic of interlocking crystals. Because the original rock was nearly pure silica, the resulting quartzite consists primarily of quartz and lacks the variety of minerals seen in other metamorphic rocks, making it extremely resistant to weathering and erosion.

165. (D) Eclogite
The presence of omphacite, a sodium-rich pyroxene, and pyrope-rich garnet is the definitive mineralogical characteristic of the eclogite facies. Eclogite is an extremely high-pressure metamorphic rock, typically formed when basaltic oceanic crust is subducted to depths of more than fifty kilometers. Its high density and specialized mineralogy make it an important rock for understanding the dynamics of the Earth's mantle and deep crustal processes.

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metamorphism and the chemical composition of the parent rock. This means that a single protolith will produce different, predictable sets of minerals at different metamorphic grades. This framework allows geologists to reconstruct the P-T history of diverse rock types.

132. (A) I and II only
Charnockites and khondalites are both characteristic of high-grade metamorphic terrains, such as those found in southern and eastern India. Charnockite is essentially an orthopyroxene-bearing granitic rock formed at granulite facies. Khondalite is a metamorphosed aluminous sediment that typically contains garnet and sillimanite. These rocks indicate extreme heat and pressure conditions in the deep crust, not low-grade metamorphism.

133. (C) Lithostatic pressure
Lithostatic pressure is the uniform pressure exerted on a rock by the weight of the overlying rock column. Similar to hydrostatic pressure in water, it acts equally in all directions and increases linearly with depth. This type of pressure primarily affects the density and volume of minerals, promoting the formation of more compact crystal structures, but it does not produce the directed alignment or foliation.

134. (A) Both A and R are true and R is the correct explanation of A
In the albite-anorthite solid solution system, anorthite is the high-temperature calcium-rich component. As a melt cools, the first crystals to form are enriched in calcium. During fractional crystallization, these crystals are removed from the system, causing the remaining liquid to become progressively enriched in sodium. Consequently, the final residual liquid will have a composition much closer to the lower-melting albite end-member.

135. (C) Basalt
Basalt is the most abundant volcanic rock on Earth. It forms the vast majority of the oceanic crust, which covers about seventy percent of the planet's surface, through eruptions at mid-ocean ridges. Basalt is also the primary component of large continental flood basalt provinces. Its widespread occurrence is due to the extensive partial melting of the Earth's mantle at various tectonic settings.

136. (A) 4, 3, 1, 2
In a typical medium-pressure regional metamorphic sequence, the facies progress from lowest to highest temperature. The sequence begins with the zeolite facies, followed by the greenschist facies at low-to-medium grades. As temperature increases further, the rock enters the amphibolite facies, and finally reaches the granulite facies at the highest temperatures. This progression reflects the increasing thermal intensity experienced by the rocks during burial.

137. (C) Andalusite
Andalusite is an aluminum silicate polymorph that is characteristic of low-pressure, high-temperature metamorphic environments. It is commonly found in the contact metamorphic aureoles surrounding igneous intrusions. While kyanite indicates high pressure and sillimanite indicates high temperature, andalusite's stability at low pressures makes it a sensitive indicator of the shallow crustal depth at which the metamorphism occurred.

138. (C) Oceanic crust and upper mantle
An ophiolite is a sequence of rocks that represents a fragment of oceanic lithosphere that has been tectonically emplaced onto continental crust. A complete ophiolite suite typically includes ultramafic mantle rocks at the base, followed by layered gabbros, sheeted dykes, pillow basalts, and a capping of deep-sea sediments. Studying ophiolites provides essential insights into the structure and composition of the ocean floor.

139. (B) Partial melting of a rock
Anatexis is the process of partial melting of pre-existing rocks, typically occurring under high-grade metamorphic conditions in the middle and lower crust. When temperatures reach a certain threshold, the felsic minerals with the lowest melting points begin to liquefy, forming a granitic melt. This process is responsible for the creation of migmatites and is a primary mechanism for generating continental granitic magmas.

140. (D) Gabbro
Ultramafic rocks are defined by having more than ninety percent mafic minerals and very low

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province. This Large Igneous Province was formed by massive volcanic eruptions during the end of the Cretaceous period. The resulting sequence consists of multiple horizontal layers of basaltic lava that cover an immense area, reaching thicknesses of several kilometers. This feature is a major component of the Indian subcontinent's geological architecture.

175. (B) Regional metamorphism
Regional metamorphism occurs over large areas, often thousands of square kilometers, and is fundamentally linked to the tectonic processes of mountain building at convergent plate boundaries. It is driven by the simultaneous increase in temperature and pressure as rocks are buried and deformed during continental collisions. This type of metamorphism produces the most common metamorphic rocks, such as schist and gneiss, which exhibit prominent foliation.

176. (B) Most forms of prograde metamorphism
Prograde metamorphism is generally considered an isochemical process, meaning that the overall chemical composition of the rock remains constant, except for the loss of volatiles like water and carbon dioxide. While minerals recrystallize and form new phases as temperature and pressure increase, the bulk concentrations of non-volatile elements typically do not change significantly. This contrasts with metasomatism or assimilation, where the rock's chemistry is substantially altered by fluids or external materials.

177. (A) P-3, Q-1, R-2, S-4
Index minerals are used to identify metamorphic grade and facies. Chlorite indicates low-grade metamorphism, while sillimanite marks high-grade, high-temperature conditions. Staurolite is characteristic of medium-grade rocks. Glaucophane is a diagnostic mineral for the high-pressure, low-temperature conditions found in subduction zones. Mapping the distribution of these minerals allows geologists to reconstruct the varying metamorphic intensities across a region and identify the underlying tectonic drivers.

178. (C) A metabasite
A metabasite is a general term for a rock formed by the metamorphism of a mafic igneous rock, such as basalt or gabbro. Depending on the metamorphic grade, these rocks can take the form of greenschists, amphibolites, or eclogites. The study of metabasites is crucial for understanding the tectonic history of an area, as their mineral assemblages are highly sensitive to changes in pressure and temperature conditions within the crust.

179. (C) Charnockite
Charnockite is a granitic-composition rock that is characterized by the presence of orthopyroxene, such as hypersthene, instead of the hydrous minerals biotite and hornblende. This mineralogy reflects high-grade granulite-facies metamorphism under anhydrous conditions. Charnockites are common in the deep crustal terrains of ancient shields, where extreme heat and low water activity favor the formation of pyroxene over hydrous silicates in felsic rocks.

180. (C) Heat, pressure, and chemically active fluids
The three primary agents of metamorphism are heat, pressure, and chemically active fluids. Heat provides the thermal energy for chemical reactions and recrystallization. Pressure, both lithostatic and directed, affects mineral density and develops foliation. Chemically active fluids, such as hydrothermal water, act as catalysts and transport ions, facilitating the growth of new minerals. Together, these agents transform pre-existing rocks into a variety of metamorphic types.

181. (A) 3, 2, 4, 1
Igneous rocks are often categorized by their silica content. Peridotite is ultramafic and has the lowest silica content, typically below forty-five percent. Gabbro is mafic with around fifty percent silica, while diorite is intermediate with about sixty percent. Granite is felsic and has the highest silica content, usually exceeding seventy percent. This progression reflects the chemical evolution of magmas from primitive mantle melts to highly evolved crustal compositions.

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149. (B) Partial melting of the metasomatized mantle wedge
The generation of andesite in subduction zones is primarily attributed to the partial melting of the mantle wedge above the subducting slab. Water and other volatiles released from the descending oceanic crust lower the melting point of the mantle rock, a process called flux melting. The resulting basaltic melt then evolves into andesite through fractional crystallization and interaction with the overlying continental or oceanic crust.

150. (B) The Eastern Ghats Belt and the Aravalli Craton
In the Indian subcontinent, alkaline igneous rocks are significantly distributed within the Eastern Ghats Belt and various parts of the Aravalli Craton. These rocks, which are enriched in alkali elements like sodium and potassium, often occur as small intrusive bodies or dykes. Their presence is frequently associated with ancient rift systems or deep-seated crustal fractures that allowed specialized mantle-derived melts to reach the crust.

151. (A) P-2, Q-4, R-1, S-3
A protolith is the original parent rock before metamorphism. An isograd is a mapped line marking the first appearance of an index mineral, which is a mineral whose presence indicates specific pressure and temperature conditions. Metamorphic grade represents the overall intensity of the process. Together, these terms provide the vocabulary for describing the transformation and mapping the intensity of metamorphic changes in the crust.

152. (D) Hornfels
Hornfels is a non-foliated metamorphic rock that typically forms during contact metamorphism. Because it is created by heat from a nearby igneous intrusion with little directed pressure, the mineral grains grow in a random, equigranular mosaic rather than aligning into layers. In contrast, gneiss, schist, and phyllite are foliated rocks that form under regional metamorphic conditions where intense directed stress is present.

153. (C) Blueschist
The mineral assemblage of glaucophane and lawsonite is diagnostic of the blueschist facies. This facies indicates high-pressure and relatively low-temperature conditions, which are characteristic of subduction zone environments. Glaucophane is a blue amphibole that gives the rock its characteristic color. Finding these minerals allows geologists to identify ancient convergent plate boundaries where oceanic crust was rapidly subducted deep into the Earth.

154. (C) Their protolith and mineral composition
The primary difference between marble and quartzite is their original parent rock and mineralogy. Marble forms from the metamorphism of limestone or dolostone and is composed mainly of calcite or dolomite. Quartzite forms from the metamorphism of quartz-rich sandstone and consists almost entirely of quartz. While both are often non-foliated and granular, their chemical properties and reactions to acid are very different.

155. (A) Both A and R are true and R is the correct explanation of A
Khondalites are recognized as high-grade supracrustal rocks because they formed from sedimentary materials that were once at the Earth's surface. Specifically, they are interpreted as metamorphosed alumina-rich shales. After deposition, these sediments were buried to great depths and subjected to granulite-facies metamorphism, transforming them into the garnet-sillimanite-quartz rocks seen today in ancient metamorphic belts like the Eastern Ghats.

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156. (C) Magma mingling/mixing
Magma mixing occurs when two chemically distinct magmas come into contact and blend to form a new magma with an intermediate composition. If the magmas do not blend completely, the process is called magma mingling, often resulting in textures like enclaves or marbled patterns. This process is a significant driver of magmatic evolution and can often trigger volcanic eruptions when hot mafic magma enters a felsic chamber.

157. (B) A liquid of a specific composition freezes at a constant temperature
A eutectic system is characterized by a specific composition, the eutectic point, at which the mixture has the lowest possible melting temperature. When a liquid of this exact

190. (C) The assemblage of garnet-sillimanite-graphite
Khondalite is characterized by a specific mineralogical assemblage that typically includes garnet, sillimanite, quartz, and often graphite. These minerals reflect the high-grade metamorphism of an aluminum-rich sedimentary protolith. The presence of sillimanite and garnet indicates that the rock reached granulite facies conditions. Khondalites are iconic rocks of the Eastern Ghats mobile belt, representing deeply buried and metamorphosed ancient sedimentary basins during the Precambrian era.

191. (B) The separation of a magma into coexisting liquids of different compositions
Liquid immiscibility is a process of magmatic differentiation where a single, homogeneous magma separates into two or more distinct liquid phases that cannot mix, similar to oil and water. This can occur due to changes in temperature or composition. For example, a silicate magma may separate into a silica-rich liquid and an iron-rich or carbonate-rich liquid, leading to the formation of igneous rocks with very different mineralogies.

192. (D) Quartz
According to Bowen's Reaction Series, quartz is the last of the common rock-forming minerals to crystallize from a cooling magma. Consequently, it is stable at the lowest temperatures relative to other minerals like olivine or pyroxene. Because it forms at conditions closest to those at the Earth's surface, quartz is also highly resistant to chemical weathering, making it a dominant mineral in many sedimentary rocks and beach sands.

193. (D) Pilotaxitic
Pilotaxitic texture is a volcanic texture characterized by randomly oriented, lath-shaped crystals, usually of plagioclase feldspar, set within an even finer-grained groundmass. Unlike trachytic texture, where the laths are aligned by magmatic flow, the crystals in a pilotaxitic texture are haphazardly arranged. This texture is common in many intermediate and mafic volcanic rocks, reflecting the rapid crystallization of the remaining melt after some crystals have already formed.

194. (B) Platinum Group Elements, Chromium, and Vanadium
The Bushveld Igneous Complex in South Africa is the world's premier source of platinum group elements, chromium, and vanadium. These economic deposits are concentrated in specific layers within the massive mafic and ultramafic intrusion. The complex's remarkable rhythmic and cryptic layering resulted from large-scale fractional crystallization and crystal settling, providing a global benchmark for understanding the processes that create world-class magmatic ore deposits within the Earth's crust.

195. (B) The melting of an igneous source rock
I-type granites are believed to be derived from the partial melting of pre-existing igneous rocks, often in the lower crust. They are typically metaluminous and contain minerals like biotite and hornblende, with little to no aluminum-rich minerals like muscovite. The I" stands for igneous, distinguishing them from S-type granites, which originate from sedimentary sources. They are common in volcanic arc settings and continental margins.

196. (B) The Nidar Ophiolite of Ladakh
The Nidar Ophiolite in the Ladakh region of the Himalayas is a prominent Indian example of an ultramafic and mafic igneous body. It represents a fragment of ancient oceanic crust and upper mantle that was tectonically emplaced during the collision between the Indian and Eurasian plates. The sequence includes peridotites, gabbros, and pillow basalts, providing crucial evidence for the geological history and tectonic evolution of the Tethys Ocean.

197. (C) Increasing temperature and lithostatic pressure from deep burial
Burial metamorphism occurs in deep sedimentary basins as layers of sediment and rock accumulate. The weight of the overlying material increases the lithostatic pressure and temperature on the rocks at the base of the sequence. This low-grade metamorphism typically produces minerals like zeolites. Unlike regional metamorphism, burial metamorphism is not associated with significant tectonic deformation or directed stress, resulting in rocks that lack prominent foliation.

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166. (B) Migmatite structure
Stromatic structure is a common texture found in migmatites, characterized by well-defined, thin, parallel layers of light-colored leucosome and dark-colored melanosome. These layers often follow the original metamorphic foliation of the parent rock. This layer-cake" appearance reflects the segregation of the partial melt into distinct sheets within the residual solid rock during the extreme heat of high-grade metamorphism, providing a visual record of partial melting.

167. (B) The sequence chlorite → biotite → garnet → staurolite → kyanite → sillimanite represents increasing metamorphic grade
The Barrovian sequence for the metamorphism of pelitic rocks is a classic model for progressive metamorphism. As temperature and pressure increase, a predictable series of index minerals appears: chlorite, then biotite, garnet, staurolite, kyanite, and finally sillimanite. Each mineral marks the beginning of a new metamorphic zone, allowing geologists to accurately map the increasing intensity of the metamorphic conditions across a regional metamorphic terrain.

168. (C) St. Thomas Mount, Madras
The term charnockite was first coined by T.H. Holland in 1893 to describe specific orthopyroxene-bearing granitic rocks found at St. Thomas Mount in Madras, now Chennai. These distinctive high-grade metamorphic rocks are widespread across the Southern Granulite Terrain. They represent the transformation of crustal materials under anhydrous, granulite facies conditions, playing a crucial role in understanding the assembly and evolution of the ancient Indian shield.

169. (C) The addition of volatiles from the subducting slab
Flux melting is a process that generates magma in subduction zones. As the oceanic slab descends, it releases volatile components, primarily water, into the overlying hot mantle wedge. These volatiles disrupt the chemical bonds in the mantle rock, significantly lowering its melting temperature. This allows the mantle to melt at a lower temperature than it would under dry conditions, producing the magmas that feed volcanic arcs.

170. (B) II only
Fractional crystallization of a basaltic magma typically removes mafic minerals like olivine and pyroxene, which are rich in magnesium and iron. This process leaves the residual liquid enriched in silica, aluminum, and alkalis, making it more felsic over time. In contrast, assimilation can make magma more felsic if the host rock is granitic, and magma mixing involves blending two magmas rather than separation into immiscible liquids.

171. (B) The early-formed solid reacts with the liquid to form a new solid phase
When a cooling liquid reaches a peritectic point under equilibrium conditions, a reaction occurs between the existing solid phase and the surrounding liquid. This reaction consumes both the liquid and the early solid to produce an entirely new solid mineral phase. This process, known as incongruent crystallization, is a key mechanism that changes the mineralogy and chemical evolution of magmatic systems as they solidify.

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172. (B) Have a common parental magma source
The term consanguineous, meaning of the same blood," is used in petrology to describe a suite of igneous rocks within a petrographic province that share a common parental magma source. Despite differences in their final mineralogy or texture, these rocks are genetically related through processes like fractional crystallization or assimilation. Their shared chemical lineage provides important clues about the magmatic history and tectonic setting of the region.

173. (B) Metasomatic replacement
The granitization hypothesis proposes that large bodies of granite can form through the solid-state metasomatic replacement of pre-existing sedimentary or metamorphic rocks. This process involves the introduction of alkalis and silica by hydrothermal fluids, which transform the original mineralogy into that of a granite without the rock ever becoming a liquid melt. While controversial, this theory was historically used to explain large-scale granite features.

174. (C) The Deccan Traps
The Deccan Traps in western and central India are a classic global example of a flood basalt

these crystals sink and accumulate at the base of the magma chamber. This process effectively removes certain chemical components from the liquid, causing the composition of the residual magma to evolve.

123. (B) Peritectic point
In phase equilibria, a peritectic point represents a specific temperature and composition where a solid phase reacts with the surrounding liquid to form an entirely different solid phase. This is known as an incongruent melting relationship. As cooling proceeds at this point, the early-formed crystals are consumed as the new mineral grows, leading to a significant change in the mineralogy of the solidifying igneous system.

124. (B) Alkali-feldspar syenite
In the IUGS QAPF classification system for plutonic rocks, the 'A' vertex represents alkali feldspar. A rock that plots at or very near this vertex consists almost entirely of alkali feldspar, with less than five percent quartz or feldspathoids. Such a rock is classified as an alkali-feldspar syenite. This naming convention ensures that the mineralogical dominance of the sample is accurately reflected in its name.

125. (C) Statement I is true but Statement II is false
Bowen's Reaction Series is a model for the crystallization sequence of magmas, but it also predicts mineral stability during weathering. Minerals that form at high temperatures, like olivine, are least stable at the surface, while low-temperature minerals like quartz are most resistant. However, the series does not accurately represent every magma type, especially those with unusual volatile contents or specialized chemical compositions.

126. (B) A single, uninterrupted, and moderately slow cooling period
Seriate texture is characterized by a continuous range of crystal sizes, from the smallest to the largest, without any distinct size gap. This implies that the rock underwent a single, uninterrupted cooling history where crystallization happened at a moderately slow and steady rate. This allowed crystals that started forming earlier to grow larger while new crystals continued to nucleate and grow as the temperature dropped.

127. (C) Formed by rapid, subaerial volcanic eruptions
Layered igneous intrusions are plutonic bodies that form from the slow cooling and crystallization of magma deep underground. They are not formed by rapid subaerial eruptions, which produce volcanic rocks. Instead, they exhibit complex internal structures like rhythmic and cryptic layering caused by crystal settling and magmatic currents. These intrusions are often economically significant as they host major deposits of precious and industrial metals.

128. (C) Low eruption temperatures and high volatile content
Carbonatite magmas are unique because they have exceptionally low eruption temperatures, sometimes as low as five hundred degrees Celsius, compared to silicate lavas. They are also characterized by extremely high volatile content, particularly carbon dioxide and water. These properties result in very low viscosity, allowing carbonatite lavas to flow easily like water, and often lead to highly explosive volcanic activity.

129. (B) Granitic intrusions
Greisenization is a specialized type of metasomatism associated with the late-stage evolution of granitic magmas. It occurs when hot, fluorine-rich acidic fluids react with the granite and surrounding country rock, transforming the original feldspars into a mixture of quartz and white mica. This process often concentrates rare elements like tin, tungsten, and lithium, making greisens important targets for mineral exploration and mining.

130. (B) Increasing grain size and degree of foliation
The progression from slate to phyllite and then to schist represents increasing metamorphic grade. As temperature and pressure rise, the minerals in the original shale protolith recrystallize and grow larger. Slate is very fine-grained, while phyllite has a visible silky sheen due to larger mica crystals. In schist, the individual mineral grains are large enough to be seen with the unaided eye, and foliation is prominent.

131. (C) Metamorphic facies
The concept of metamorphic facies is based on the principle that the mineral assemblage of a metamorphic rock is determined by the pressure and temperature conditions during

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182. (C) Olivine will start to react with the melt to form pyroxene
In the forsterite-fayalite-silica ternary system, the boundary between the olivine and pyroxene crystallization fields marks a peritectic reaction. When a cooling melt reaches this boundary, early-formed olivine crystals become unstable and react with the silica-rich liquid to form pyroxene. This incongruent reaction is a fundamental step in the crystallization of basaltic magmas, demonstrating how minerals can be transformed into new phases as the melt's chemistry evolves.

183. (C) Carbonatites and Lamprophyres
The IUGS QAPF classification system is designed for standard silicate igneous rocks based on the relative proportions of quartz, feldspars, and feldspathoids. However, it is not suitable for rocks with unusual compositions like carbonatites, which are dominated by carbonate minerals, or lamprophyres, which have specialized mineralogies and textures. These rocks require separate, specialized classification schemes that account for their unique chemical and mineralogical characteristics.

184. (B) The accumulation of crystals that settled from a magma
A cumulate texture forms in an igneous rock when crystals that have grown in a magma chamber settle out of the liquid and accumulate into a layer. This often happens under the influence of gravity or magmatic currents. The resulting rock consists of an interlocking framework of these accumulated crystals, called cumulus grains, with the spaces between them filled by later-crystallizing minerals from the residual interstitial liquid.

185. (C) Large metamorphic crystals in a finer-grained matrix
A porphyroblastic texture is characterized by large, well-formed crystals, called porphyroblasts, embedded in a finer-grained metamorphic matrix. These minerals, such as garnet, staurolite, or kyanite, grow in the solid state as the rock is subjected to heat and pressure. Their large size compared to the surrounding grains is due to their higher rate of crystal growth and their stability over a wide range of metamorphic conditions.

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186. (C) It is a process that homogenizes the rock composition
Metamorphic differentiation is a process that increases the heterogeneity of a rock by segregating its chemical components into distinct mineralogical bands. It does not homogenize the composition. Mechanisms such as pressure solution and ion migration cause minerals to separate into alternating light and dark layers, creating textures like gneissic banding. This process transforms a relatively uniform parent rock into one with clear mineralogical and chemical segregation.

187. (D) High temperature and high pressure
The eclogite facies represents conditions of extremely high pressure and high temperature. These conditions are typically found in the upper mantle or the deep roots of thickened continental crust during major orogenic events. Eclogite is composed primarily of omphacite pyroxene and pyrope-rich garnet and is the high-pressure equivalent of mafic rocks like basalt. Its extreme density makes it significant for the gravitational stability of crustal roots.

188. (B) Migmatites
Agmatite and schollen are terms used to describe specific structures within migmatites. Agmatite refers to a breccia-like structure where angular fragments of the darker residual rock, or melanosome, are enclosed in a light-colored granitic matrix, or leucosome. Schollen describes a similar structure but with larger, raft-like fragments of the host rock. These features provide visual evidence of the partial melting and internal deformation that occur during high-grade metamorphism.

189. (A) Greenschist → Amphibolite → Granulite
During the prograde metamorphism of a typical mafic rock like basalt, the mineral assemblages change in a predictable sequence of facies as temperature and pressure increase. The sequence begins with the low-grade greenschist facies, characterized by chlorite and actinolite. As the grade increases, it enters the amphibolite facies with hornblende and plagioclase, and finally reaches the high-temperature granulite facies, where anhydrous minerals like pyroxene become stable.

silica content. Peridotite, dunite, and pyroxenite all meet this criterion. Gabbro, however, is a mafic rock because it contains a significant proportion of plagioclase feldspar in addition to ferromagnesian minerals. While gabbro is dark and dense, its mineralogy and higher silica content distinguish it from the ultramafic category.

141. (A) Decompression melting
At divergent plate boundaries, such as mid-ocean ridges, magma is primarily generated by decompression melting. As the tectonic plates pull apart, the underlying solid mantle rises to fill the gap. Because the pressure decreases as the mantle rock ascends while its temperature remains high, the rock crosses its melting point and begins to partially melt, producing the basaltic magmas of the oceanic crust.

142. (B) The squeezing of interstitial liquid from a crystal mush
Filter pressing is a mechanism of magmatic differentiation where mechanical stress is applied to a mixture of crystals and liquid, known as a crystal mush. This stress, often from tectonic forces or the weight of overlying crystals, squeezes the residual liquid out from the interstitial spaces between the grains. This separation allows the fractionated liquid to move elsewhere, creating magmas with distinct chemical compositions.

143. (C) Peritectic reaction
In the forsterite-fayalite-silica ternary system, the boundary between the olivine and pyroxene crystallization fields represents a peritectic reaction. At this boundary, early-formed olivine crystals react with the surrounding silica-rich melt to produce pyroxene. This is an incongruent relationship where the solid and liquid react to form a new solid phase. This reaction is fundamental for understanding the mineralogical evolution of mafic magmas during cooling.

144. (C) Rhyolite
Rhyolite is the volcanic equivalent of granite. Both rocks have a felsic composition, meaning they are rich in silica, aluminum, and alkalis, and typically contain quartz and alkali feldspar. While granite forms from slow cooling deep underground and has large crystals, rhyolite forms from the rapid cooling of lava at or near the surface, resulting in a fine-grained or even glassy texture.

145. (B) A predictable sequence of mineral crystallization from a cooling magma
A reaction series in igneous petrology describes the orderly sequence in which minerals crystallize and react with the remaining melt as a magma cools. Bowen's Reaction Series is the most famous example, categorizing minerals into continuous and discontinuous branches. This concept explains why certain minerals are commonly found together and how the chemical composition of the residual magma evolves over time.

146. (A) Granophyric or Eutectic texture
Graphic texture consists of an intimate, regular intergrowth of quartz and alkali feldspar, where the quartz grains resemble cuneiform or ancient writing. This is a specific type of granophyric texture that often forms during the simultaneous crystallization of these two minerals at the eutectic point. It is commonly found in certain types of granites and pegmatites, indicating rapid, simultaneous growth from a late-stage melt.

147. (B) Systematic variation in mineral chemical composition with height
Cryptic layering in a layered igneous intrusion refers to systematic changes in the chemical composition of individual minerals with their stratigraphic height, which cannot be seen with the naked eye. For example, plagioclase may become more sodium-rich and olivine more iron-rich as you move up through the intrusion. This layering provides vital evidence of the continuous fractional crystallization of the cooling magma body.

148. (D) Peraluminous
S-type granites are derived from the partial melting of sedimentary source rocks, such as shales or pelites. Because these protoliths are typically rich in aluminum from weathered clay minerals, the resulting granites are peraluminous. This means they contain more aluminum than can be accommodated in feldspars, leading to the formation of aluminum-rich minerals like muscovite, garnet, or occasionally aluminosilicates like sillimanite.

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198. (A) Both Statement I and Statement II are true
Dynamic metamorphism is dominated by mechanical processes, such as the crushing and grinding of rocks along fault zones. In the ductile regime at greater depths, this intense shear stress produces mylonites, which are rocks characterized by a fine-grained, foliated texture and evidence of significant strain. These rocks provide a record of the intense deformation and movement that occurs along major tectonic boundaries within the Earth's crust.

199. (B) A fragment of a pre-existing large crystal that has been deformed
A porphyroclast is a relatively large crystal in a metamorphic rock that is a remnant of the original rock's mineralogy. During intense deformation, such as in a shear zone or during the formation of a mylonite, the surrounding material is ground down and recrystallized into a finer matrix, while the stronger porphyroclast remains as a visible, often Augen-shaped, fragment. It contrasts with a porphyroblast, which is a newly grown crystal.

200. (A) A unique pressure and temperature condition (~5.5 kbar, ~600°C)
Andalusite, kyanite, and sillimanite are all polymorphs of aluminum silicate. The presence of all three minerals together in a single rock indicates that the metamorphism occurred exactly at the triple point" on their phase diagram. This point represents a unique set of pressure and temperature conditions, approximately 5.5 kilobars and 600 degrees Celsius. Such occurrences are rare and provide a precise calibration point for reconstructing ancient metamorphic environments.

201. (B) P-3, Q-2, R-1, S-4
Basalt is characteristic of mid-ocean ridges and hotspots, while andesite is synonymous with subduction zones. Granites commonly form in continental collision or intraplate settings through the melting of crustal material. Alkaline rocks are often associated with continental rift zones where specialized mantle melting occurs. Matching these rock types to their typical tectonic environments is a fundamental principle in global petrology and tectonic reconstruction.

202. (A) Both A and R are true and R is the correct explanation of A
In the ternary system involving albite, anorthite, and diopside, the temperature of the liquid decreases as crystallization proceeds. The final liquid in the system will always migrate toward the ternary eutectic point, which represents the lowest possible temperature where a melt can coexist with the solid phases. Once this point is reached, the remaining liquid solidifies at a constant temperature, completing the crystallization of the magmatic system.

203. (B) N. L. Bowen
The Reaction Principle was a ground breaking concept proposed by Norman L. Bowen in the early 20th century. Through his experimental work, Bowen demonstrated that minerals crystallize from a cooling magma in a predictable sequence and react with the remaining liquid to form new phases. This principle forms the basis of Bowen's Reaction Series, which remains a fundamental framework for understanding the chemical and mineralogical evolution of all igneous rocks.

204. (D) I, II and III
Igneous textures provide essential clues about the cooling history and origin of a rock. A phaneritic texture with visible crystals indicates a slow cooling intrusive origin, while a glassy texture signifies very rapid extrusive cooling. A porphyritic texture, with two distinct crystal sizes, records a complex multi-stage cooling history where the magma experienced different thermal environments. Together, these textures allow geologists to reconstruct the magmatic journey from depth to the surface.

205. (C) Metasomatism
Graphitization is best described as an extreme form of metasomatism, where pre-existing rocks are transformed into granite through solid-state chemical replacement. This process involves the large-scale introduction of alkalis and silica by hydrothermal fluids and the removal of other elements. While it shares some features with high-grade regional metamorphism, its reliance on significant chemical change and replacement by fluids without a fully molten stage defines it as a metasomatic process.

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or more distinct, coexisting liquid phases that cannot mix. This is analogous to how oil and water separate. This phenomenon can occur in specialized magma types, such as the separation of a carbonate melt from a silicate melt in carbonatite systems, or the formation of an iron-rich liquid from a cooling silicate magma.

238. (C) Complete solid solution
In the binary system involving albite and anorthite, which are the sodium and calcium end-members of the plagioclase feldspar group, there is complete solid solution. This means that sodium and calcium ions can freely substitute for one another in the crystal lattice across the entire range of compositions. On a phase diagram, this relationship is shown as a continuous loop without any eutectic point, reflecting the smooth chemical evolution of plagioclase during crystallization.

239. (B) Komatiite
A komatiite is a rare, high-magnesium ultramafic volcanic rock that fits the IUGS criteria for ultramafic volcanic compositions. These rocks are characterized by magnesium oxide content exceeding eighteen percent and very low concentrations of alkali elements. Komatiites are primarily found in Archean greenstone belts and are famous for their unique spinifex texture. They formed from extremely hot, low-viscosity lavas that are no longer produced in the modern, cooler mantle environment of the Earth.

240. (A) P-3, Q-4, R-1, S-2
Aphanitic texture involves crystals too small to see with the unaided eye, while phaneritic texture features large, visible crystals. Porphyritic texture is characterized by large phenocrysts in a finer matrix, and glassy texture describes a non-crystalline, amorphous state. These textural terms are fundamental for describing igneous rocks and provide immediate insights into their cooling history, with fine-grained textures indicating rapid cooling and coarse-grained textures indicating slow cooling at depth.

241. (D) I, II and III
A petrographic province is a geographic area where the igneous rocks show a close relationship in terms of space, time, and chemical composition. The Deccan Traps in India are a major example of such a province, consisting of related flood basalts. Rocks within these provinces are described as consanguineous, implying a shared genetic lineage from a common parental magma source. These regions are essential for studying large-scale magmatic processes and tectonic evolution.

242. (B) Anatexis
Anatexis is the process of generating granitic magma through the partial melting of pre-existing continental crustal rocks. This typically occurs in the middle and lower crust when temperatures reach the threshold required to melt felsic minerals. Anatexis is a key mechanism for creating large volumes of felsic magma during mountain-building events and is responsible for the formation of migmatites, which show direct evidence of the transition from solid rock to melt.

243. (C) Komatiites
Spinifex texture is diagnostic for komatiites, which are rare ultramafic volcanic rocks. The texture consists of long, bladed or needle-like crystals of olivine or pyroxene that form a criss-cross pattern. This unique arrangement is thought to be the result of extremely rapid quenching from very high-temperature, low-viscosity lavas. Spinifex texture is a primary identifying feature used by geologists to recognize ancient Archean volcanic sequences that represent exceptional mantle thermal conditions.

244. (B) Burial metamorphism
Burial metamorphism occurs as rocks are deeply buried within massive sedimentary basins. The increasing weight of the overlying material causes a gradual rise in both lithostatic pressure and temperature. This relatively low-grade process typically occurs without significant tectonic deformation or directed stress, so the resulting rocks usually lack foliation. It is characterized by the formation of minerals like zeolites and represents the early stage of metamorphic transformation of buried crustal materials.

245. (A) The preferred linear alignment of minerals or structural features
Lineation in a metamorphic rock refers to the preferred alignment of linear or elongated features, such as needle-like minerals, stretched pebbles, or mineral streaks. This structural fabric

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is the hallmark of Bowen's continuous reaction series. As the magma cools, the plagioclase crystals constantly react with the surrounding melt, exchanging calcium and aluminum for sodium and silica. Because the internal crystal structure remains the same throughout this process, the composition evolves smoothly and continuously, reflecting the changing chemical balance between the solid and liquid phases.

215. (D) Minerals that crystallized and accumulated, usually by settling
A cumulus phase in a layered igneous intrusion refers to the minerals that crystallized from the magma and then accumulated on the floor or walls of the chamber. This accumulation is typically caused by gravity-driven settling or magmatic currents. These crystals form the structural framework of the resulting rock. The spaces between the cumulus grains are eventually filled by minerals that crystallize from the remaining interstitial liquid, known as post-cumulus material.

216. (B) Anorogenic, A-type granites and rhyolites
The Malani Igneous Suite in Rajasthan is an extensive Neoproterozoic magmatic province in India. It is famous for its large volumes of A-type granites and rhyolites, which are characterized by high silica and alkali content. These rocks formed in an anorogenic setting, meaning they were not directly associated with active mountain building. This province represents a major silicic volcanic event, potentially related to crustal extension or mantle plume activity during the breakup of ancient supercontinents.

217. (C) High-temperature, low-pressure contact metamorphism
Hornfels is a metamorphic rock that typically forms during high-temperature, low-pressure contact metamorphism. It is created in the bake zones surrounding igneous intrusions, where the heat from the magma causes the adjacent country rock to recrystallize. Because this process lacks significant directed stress, the resulting hornfels is non-foliated and fine-grained, with a tough, granular texture. It represents the purely thermal transformation of various parent rocks, such as shale or basalt.

218. (C) A line connecting points of first appearance of an index mineral
An isograd is a line on a geological map that connects locations where a specific index mineral first appears in the field. It represents a boundary of equal metamorphic grade, marking the specific pressure and temperature conditions required for that mineral to form from its precursor phases. By mapping a series of isograds, geologists can determine the direction and intensity of metamorphic changes across a regional metamorphic terrain.

219. (C) Metasomatism
Metasomatism is a metamorphic process that involves the significant alteration of a rock's bulk chemical composition through the introduction or removal of chemical species by a fluid phase. These hydrothermal fluids, often rich in dissolved ions, react with the original minerals to form new ones. This process differs from isochemical metamorphism, where the chemistry remains largely unchanged, and is often responsible for the formation of specialized rocks and economic mineral deposits near igneous intrusions.

220. (A) Dolomitic marble
The metamorphism of pure dolomite, which is a magnesium-calcium carbonate, results in the formation of dolomitic marble. During this process, the dolomite crystals recrystallize into a larger, interlocking mosaic of new dolomite grains. Unlike impure carbonates, which can form a variety of calc-silicate minerals, pure dolomite lacks the silica and other components needed for such reactions, resulting in a non-foliated rock composed almost entirely of recrystallized dolomite.

221. (B) 1, 2, 3, 4
The evolution of a complex magma chamber typically begins with the intrusion of a primary magma. As it cools, fractional crystallization starts, leading to the settling of early-formed mafic crystals like olivine. Simultaneously, the magma may incorporate and melt surrounding felsic country rock through assimilation. These combined processes change the magma's composition, eventually leading to the eruption of a more evolved, silica-rich magma that differs significantly from the original intrusion.

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206. (B) The Deccan Plateau
In India, the most famous and extensive occurrences of basalt are found on the Deccan Plateau. This region constitutes the Deccan Traps, a vast Large Igneous Province formed by massive volcanic eruptions during the late Cretaceous. The thick sequence of nearly horizontal basaltic lava flows covers an immense area of western and central India, creating a distinctive landscape and representing one of the most significant volcanic events in Earth's history.

207. (C) Dynamic
Dynamic metamorphism is the primary process responsible for the formation of mylonites. It occurs in areas of intense shear stress and directed pressure, typically within fault and shear zones. The high strain causes the rock to undergo ductile deformation and recrystallization, resulting in a fine-grained, strongly foliated rock. Mylonites provide critical evidence of the mechanical and thermal processes that occur during significant tectonic movement within the Earth's crust.

208. (B) Foliation
Foliation is the general term for any planar fabric or layering in a metamorphic rock. It is produced by the parallel alignment of platy or elongated minerals, such as mica or amphibole, in response to directed pressure or differential stress. Examples of foliation include slaty cleavage, schistosity, and gneissic banding. This structural feature is a key indicator of the tectonic forces and metamorphic conditions the rock experienced during its formation.

209. (B) Medium P / Medium T
The Barrovian sequence of metamorphic zones, which follows a progression from chlorite to sillimanite, represents a medium-pressure and medium-temperature metamorphic path. This is the most common type of metamorphism associated with large-scale continental collisions and mountain building. The steady increase in both temperature and pressure as rocks are buried and heated within the thickened crust creates the characteristic sequence of index minerals mapped in many regional metamorphic belts.

210. (C) Partial melting of the host rock
The formation of a migmatite requires temperatures high enough to cause the partial melting of the host rock, a process known as anatexis. This typically occurs at the transition between high-grade metamorphism and the generation of magma. The rock becomes a mixture of a solid residual portion and a newly formed granitic melt. This process results in the complex, composite textures that define migmatites as the highest-grade metamorphic rocks.

211. (A) Silica content and temperature
The viscosity of a magma is primarily controlled by its silica content and temperature. Magmas with higher silica content, like rhyolite, are more viscous because the silica tetrahedra form long, complex chains that resist flow. Conversely, higher temperatures decrease viscosity by providing the energy to break these chains. Consequently, hot basaltic magmas are relatively fluid, while cooler granitic magmas are extremely thick and move very slowly.

212. (B) The liquid solidifies at a constant temperature as a fine-grained intergrowth
In a simple binary eutectic system, if the starting liquid has exactly the eutectic composition, it will cool until it reaches the eutectic temperature. At this point, the entire liquid will solidify simultaneously into two or more solid phases at a constant temperature. This results in a distinctive, fine-grained inter growth of the minerals, as they all crystallize at once without any one mineral having the chance to grow large beforehand.

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213. (D) More than 60% feldspathoid minerals
According to the IUGS classification for volcanic rocks, a rock is named a foidite if it contains more than sixty percent feldspathoid minerals in its total proportion of quartz, feldspars, and feldspathoids. These rocks are extremely silica-undersaturated and contain minerals like nepheline or leucite instead of quartz. The high percentage of these specialized minerals reflects a unique magma chemistry that is deficient in silica but enriched in alkali elements.

214. (C) Continuous reaction series
The change in plagioclase feldspar composition from calcium-rich to sodium-rich during cooling

surface or erupted as lava, preventing additional large crystals from growing.

230. (A) Flux melting in subduction zones
The origin of andesitic magmas is most closely linked to flux melting at convergent plate boundaries. As an oceanic plate subducts, it releases water and other volatiles into the overlying mantle wedge. This lowers the melting point of the mantle rock, causing it to partially melt and produce basaltic magmas. These magmas then evolve into andesite through fractional crystallization and assimilation of continental crust as they rise toward the surface, forming volcanic arcs.

231. (C) Diagenesis
The primary agents of metamorphism are elevated temperature, directed pressure, and chemically active fluids, all of which drive recrystallization and mineral changes. Diagenesis, however, refers to the lower-temperature and lower-pressure processes that occur during the burial and lithification of sediments into sedimentary rocks. Because it takes place at conditions below the threshold for metamorphism, diagenesis is not considered an agent of the metamorphic transformation that creates rocks like schist or marble.

232. (C) Fine-grained, granular, and non-foliated appearance
Hornfelsic texture is characterized by a fine-grained, equigranular mosaic of interlocking crystals that lack any preferred orientation or foliation. This texture is the hallmark of contact metamorphism, where heat from an igneous intrusion is the dominant agent of change. Because there is no significant directed stress to align the growing minerals, the resulting rock, or hornfels, is tough and uniform, reflecting the purely thermal recrystallization of the original parent rock.

233. (B) Greenschist facies
A metamorphic rock belonging to the greenschist facies is characterized by an abundance of green-colored minerals, particularly chlorite, actinolite, and epidote. These minerals form under low-to-medium grade regional metamorphic conditions, typically at temperatures between three hundred and four hundred fifty degrees Celsius. The presence of these specific hydrous minerals in metamorphosed mafic rocks like basalt is a diagnostic indicator of the relatively low-temperature thermal regime the rock experienced during burial.

234. (A) A granitic intrusion contacts carbonate sedimentary rocks
Skarns are metasomatic rocks that typically form at the contact between a granitic or silicic igneous intrusion and carbonate-rich sedimentary rocks like limestone. The high-temperature hydrothermal fluids from the cooling magma carry silica, iron, and other elements into the carbonate rock, where they react with calcium and magnesium. This process creates a complex assemblage of calc-silicate minerals, such as garnet and pyroxene, and is often a major source of metal ores.

235. (A) Hornblende and Plagioclase
The metamorphism of mafic rocks, such as basalt or gabbro, at medium to high grades primarily results in the formation of hornblende and plagioclase feldspar. This mineral assemblage is characteristic of the amphibolite facies, which reflects temperatures between five hundred and seven hundred degrees Celsius. The transition from low-grade minerals like chlorite to these more stable high-temperature minerals marks the progression into higher metamorphic intensities during regional mountain-building events in the crust.

236. (B) The melt, crystals, and dissolved volatiles together
The term magma refers to the entire mobile mixture of material found beneath the Earth's surface. This encompasses the liquid portion, known as the silicate melt, any solid crystals of minerals that have already begun to crystallize and are suspended within that liquid, and the dissolved volatile gases such as water vapor and carbon dioxide. Understanding magma as a multi-phase system is essential for modeling its physical behavior and chemical evolution during cooling.

237. (B) Liquid immiscibility
Liquid immiscibility is a process of magmatic differentiation where a single, initially homogeneous magma body separates into two

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the surrounding liquid to produce an entirely new solid phase. As cooling progresses at the peritectic boundary, early-formed olivine crystals are consumed while pyroxene crystals grow. This reaction is fundamental for understanding the mineralogical changes that occur as basaltic magmas evolve and cool.

254. (C) Pumice
Pumice is a volcanic rock characterized by an extremely high proportion of voids, or vesicles, which are formed by the rapid expansion of gas bubbles during an explosive eruption. Because these vesicles make the rock exceptionally porous and light, pumice is the only rock known to have a density low enough to float on water. It is typically felsic in composition and forms from the rapid quenching of frothy, gas-charged lava, often associated with rhyolitic volcanism.

255. (B) The intrusion and slow cooling of granitic magma
A large, discordant granitic batholith is formed through the slow cooling and crystallization of a massive body of felsic magma deep within the Earth's crust. As the magma rises and intrudes into the surrounding country rock, it cuts across existing structures. The slow cooling environment provided by the deep crust allows for the growth of the large, interlocking crystals that characterize a phaneritic texture. This magmatic origin is supported by the presence of intrusive contacts.

256. (B) Ultramafic rocks have a higher percentage of ferromagnesian minerals
The primary distinction between mafic and ultramafic rocks is the volume percentage of ferromagnesian, or mafic, minerals like olivine and pyroxene. Ultramafic rocks, such as peridotite and dunite, contain more than ninety percent mafic minerals and very little silica or feldspar. Mafic rocks, like basalt and gabbro, have a significant proportion of ferromagnesian minerals but also contain a substantial amount of plagioclase feldspar, placing them lower on the color index than ultramafic varieties.

257. (B) Shock metamorphism
Shock metamorphism is a unique type of metamorphism that occurs exclusively during high-velocity meteorite impacts. The extreme, instantaneous pressure and temperature generated by the impact cause specialized changes in the target rocks, such as the formation of high-pressure silica polymorphs like coesite or the development of planar deformation features in quartz. These effects are only found at impact sites and provide definitive evidence of cosmic collisions throughout the Earth's long geological history.

258. (B) Schist
A rock displaying a schistose texture is called a schist. This texture is characterized by the parallel alignment of visible, platy minerals, most commonly mica, which give the rock a distinctive sheen. Schist forms during regional metamorphism of medium grade. The alignment of minerals occurs in response to directed pressure, allowing the rock to split into thin flakes or layers. Schists can form from various protoliths, including pelites and mafic igneous rocks.

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259. (A) Facies are theoretical P-T fields, while zones are mappable areas
Metamorphic facies and metamorphic zones are complementary concepts. A facies represents a theoretical range of pressure and temperature conditions that produce specific mineral assemblages across different rock types. In contrast, a metamorphic zone is a specific, mappable geographic area on the ground defined by the presence of a particular index mineral. While a zone describes the physical distribution of metamorphic intensity, a facies provides the underlying thermodynamic framework for understanding those changes.

260. (C) Carbonatites and alkaline complexes
Fenites are specialized metasomatic rocks that form in the halo surrounding carbonatite or alkaline igneous complexes. They are created by the process of fenitization, where alkali-rich fluids from the intrusion react with the surrounding country rock. This transformation results in the replacement of original minerals with new alkaline varieties, such as aegirine and sodic amphiboles. The presence of fenites is a key diagnostic indicator for identifying the deep-seated influence of alkaline magmatic activity.

provides important clues about the direction of tectonic transport and strain the rock experienced during deformation. Unlike foliation, which is a planar feature, lineation describes a one-dimensional orientation that results from intense stretching or rotational forces within the Earth's crust during metamorphism.

246. (C) Staurolite
In the Barrovian sequence of progressive regional metamorphism, staurolite is the index mineral that typically appears after garnet and before kyanite. Its appearance marks the transition into medium-grade metamorphic conditions. Staurolite forms through the reaction of lower-grade minerals like biotite and garnet as temperature and pressure increase. Its presence in metamorphosed pelitic rocks is a reliable indicator of the specific thermal and burial history within a mountain-building tectonic environment.

247. (D) Basalt
Eclogite is an extremely dense, high-pressure metamorphic rock that is the chemical equivalent of basalt. When basaltic oceanic crust is subducted to great depths, it undergoes intense metamorphism, transforming into an assemblage of omphacite pyroxene and garnet. This transformation is significant because eclogite is much denser than the original basalt, providing a powerful gravitational pull that helps drive the process of plate subduction and mantle convection throughout geological time.

248. (A) Melanosome
A migmatite is composed of two primary mineralogical components that reflect its history of partial melting. The leucosome is the light-colored, granitic part that crystallized from the newly formed melt. The melanosome is the dark-colored, mafic-rich part that represents the residual solid rock remaining after the melt was extracted. Together, these two parts, often organized into a layered or stromatic structure, provide clear visual evidence of the high-grade metamorphic process called anatexis.

249. (C) Skarn
When a granite pluton intrudes into a limestone body, the heat and hydrothermal fluids from the magma cause contact metasomatism, resulting in the formation of a skarn. The fluids introduce silica and iron, which react with the calcium in the limestone to produce a variety of calc-silicate minerals such as garnet and pyroxene. Skarns are typically very coarse-grained and complex in mineralogy, and they are often targets for mining metal ores like tungsten or copper.

250. (B) Charnockite and Khondalite
Charnockites and khondalites are the two iconic rock types characteristic of the high-grade granulite facies terrains of southern and eastern India. Charnockite is an orthopyroxene-bearing granitic rock, representing the deep, anhydrous crust. Khondalite is a metamorphosed aluminous sediment, typically containing garnet and sillimanite. Their close association in ancient mobile belts provides essential information about the extreme thermal and tectonic processes that shaped the Precambrian foundation of the Indian subcontinent.

251. (D) Isostatic rebound
Magma composition can be significantly altered by internal processes like fractional crystallization and external processes such as assimilation and magma mixing. These mechanisms allow a single source melt to evolve into various igneous rock types. Isostatic rebound, however, is a large-scale tectonic process involving the vertical rise of the Earth's crust after the removal of a weight, such as an ice sheet. It is unrelated to the chemical and mineralogical evolution of magmas.

252. (A) The relative proportions of liquid and solid phases present
The lever rule is a mathematical tool used in binary phase diagrams to calculate the relative weight proportions of the coexisting phases, such as liquid and solid, at a specific temperature. By measuring the lengths of the lever arms" from the bulk composition to the liquidus and solidus boundaries, geologists can determine exactly how much of the system has crystallized and how much remains as melt during the cooling process.

253. (C) Peritectic reaction
The reaction between olivine and a silica-rich liquid to form pyroxene is a classic example of a peritectic reaction. This is an incongruent melting relationship where a solid phase reacts with

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powerful tool for reconstructing the ancient tectonic and thermal environments of the Earth's crust. This facies concept remains the foundation for modern metamorphic petrology and tectonic studies worldwide.

269. (B) The newly formed part of the rock
In the context of a migmatite, the term neosome refers to the newly formed portion of the rock that was created during the process of partial melting, or anatexis. The neosome is composed of two parts: the light-colored leucosome, which represents the crystallized melt, and the dark-colored melanosome, which is the residual solid rock. The neosome is distinguished from the paleosome, which represents the original, unmelted parent material that survived the high-grade metamorphic event.

270. (C) A high-grade granulite facies terrain
In the Eastern Ghats belt of India, the close association of charnockites and khondalites is characteristic of a high-grade granulite facies terrain. Charnockites represent the deep, anhydrous felsic crust, while khondalites are the metamorphosed equivalents of aluminum-rich sedimentary rocks. Together, they record the extreme temperature and pressure conditions that occurred during ancient Precambrian mountain-building events. This terrain provides vital insights into the thermal and tectonic evolution of the deep continental lithosphere.

271. (A) Temperature decreases and silica content increases
Magma becomes more viscous when its temperature decreases and its silica content increases. As silica content rises, more silica tetrahedra form, creating complex and interconnected chains that resist movement. Lowering the temperature reduces the thermal energy available to break these molecular bonds, further increasing the resistance to flow. This explains why relatively cool, silica-rich granitic magmas are far more viscous and move much more slowly than hot, silica-poor basaltic magmas.

272. (B) A path along which two solid phases crystallize together
A cotectic line on a ternary phase diagram represents a specific boundary between the primary crystallization fields of two different solid minerals. As a magma cools and its composition evolves, it eventually reaches this line. Once on the cotectic, the remaining liquid is in equilibrium with both minerals, which then begin to crystallize simultaneously. This process continues as the temperature drops, moving the liquid composition toward a eutectic or peritectic point.

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273. (D) Quartz
According to Bowen's Reaction Series, quartz is the last of the common rock-forming minerals to crystallize from a cooling magma. Consequently, it is stable at the lowest temperatures and pressures, which are closest to the conditions at the Earth's surface. This thermal stability, combined with its lack of cleavage and strong chemical bonds, makes quartz exceptionally resistant to chemical weathering. This resistance is why quartz is the dominant component of most beach sands and sandstones.

274. (B) Rapid cooling and devitrification of a glassy rock
Spherulitic texture consists of small, spherical masses of radiating mineral fibers, typically quartz and feldspar. This texture is formed by the rapid cooling of silica-rich lavas, often as the resulting glass undergoes devitrification. Devitrification is the process where atoms within the amorphous glass slowly reorganize into crystals. The radial growth pattern is a common feature in volcanic rocks like rhyolite and provides evidence of the rapid quenching and subsequent crystallization history.

275. (A) Liquid immiscibility from a parental silicate magma
The origin of carbonatites is a subject of debate, but one prominent theory suggests they form through liquid immiscibility. In this process, a silicate magma becomes unstable and separates into two coexisting but distinct liquids, similar to oil and water. One liquid is silicate-rich, and the other is carbonate-rich. This separation allows the rare carbonate magma to move and erupt or intrude independently, leading to the formation of these unique, silica-poor igneous rocks.

261. (A) Both A and R are true and R is the correct explanation of A
Assimilation occurs when magma incorporates and melts chunks of the surrounding country rock, which can significantly change its chemical composition. For this to happen, the magma must possess sufficient thermal energy, known as superheat, to raise the temperature of the solid rock and provide the latent heat for melting. If the magma is already at its crystallization temperature, it cannot assimilate large amounts of rock without also solidifying itself in the process.

262. (A) Quartz, Alkali Feldspar, Plagioclase, Feldspathoid
The IUGS QAPF classification system for plutonic rocks is based on a double-triangular diagram whose four vertices are quartz, alkali feldspar, plagioclase, and feldspathoid minerals. By determining the relative modal percentages of these four components, geologists can systematically name coarse-grained igneous rocks. This system ensures that the nomenclature accurately reflects the primary mineralogy of the sample. Separate diagrams are used for rocks that are predominantly mafic or contain significant amounts of other specialized minerals.

263. (A) 2, 4, 3, 1
During the progressive regional metamorphism of a shale protolith, the rock transforms into a series of different types as temperature and pressure increase. The sequence begins with fine-grained slate, followed by phyllite, which has a silky sheen. As the grain size increases further, the rock becomes a schist with visible platy minerals. Finally, at the highest grades, it develops into gneiss, characterized by distinct mineral banding and high-temperature mineral assemblages.

264. (B) Greater than 100 km^2
A batholith is a massive, discordant intrusive igneous body that has an exposed surface area of more than one hundred square kilometers. These features are typically granitic in composition and form through the slow cooling of enormous volumes of magma deep within the Earth's crust. Batholiths often represent the solidified remains of the deep-seated plumbing systems that once fed large volcanic chains. Smaller intrusive bodies with less than one hundred square kilometers exposure are called stocks.

265. (A) Wollastonite
When a limestone containing quartz sand impurities undergoes metamorphism, the calcium carbonate reacts with the silica to form calc-silicate minerals. Wollastonite is a classic example of such a mineral, forming through the reaction of calcite and quartz at relatively high temperatures. This process involves the release of carbon dioxide as a byproduct. The presence of wollastonite is a sensitive indicator of the specific temperature and fluid conditions during the metamorphism of impure carbonate rocks.

266. (C) Peralkaline
A magma is termed peralkaline when the total molecular proportion of its alkalis, specifically sodium and potassium oxide, exceeds the molecular proportion of aluminum oxide. This chemical imbalance means that there is more alkali content than can be accommodated in common feldspar minerals. Consequently, peralkaline magmas often crystallize specialized minerals such as sodic pyroxenes and amphiboles, reflecting their unique chemical signature. This composition is typical of certain alkaline volcanic and plutonic suites.

267. (B) The presence or absence of significant directed stress
The fundamental control over whether a metamorphic rock is foliated or non-foliated is the presence or absence of directed stress, also known as differential pressure. Under directed stress, minerals like mica grow or rotate into a parallel alignment, creating a foliated fabric like schistosity. In environments where stress is uniform, such as in contact metamorphism, minerals grow in random orientations, resulting in non-foliated rocks like hornfels or marble. Protolith composition also plays a secondary role.

268. (B) Pentti Eskola
The concept of metamorphic facies was first proposed by the Finnish petrologist Pentti Eskola in the early 20th century. He recognized that different mineral assemblages could form from the same parent rock under different temperature and pressure conditions. By grouping these assemblages together, Eskola provided a

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222. (B) Observation of gradational contacts and 'ghost' stratigraphy in granite bodies
A key argument for the granitization theory is the observation of gradational contacts between granite bodies and the surrounding metamorphic rocks, rather than sharp intrusive boundaries. Furthermore, some granites exhibit ghost" stratigraphy, where the structural fabric or bedding of the original sedimentary or metamorphic rock can still be traced into the granite. Proponents of granitization argued that these features evidenced a solid-state transformation of the rock into granite via metasomatic processes.

223. (C) Blueschist
Glaucophane is a blue-colored sodic amphibole that is the definitive index mineral for the blueschist facies. This facies is characteristic of high-pressure and low-temperature metamorphic conditions, which occur primarily in subduction zones where oceanic crust is rapidly buried. Finding glaucophane in a metamorphic rock is a clear indicator that the rock was once part of an ancient convergent plate boundary, reflecting the unique tectonic environment of cold oceanic slab descent.

224. (C) Migmatite
A rock that shows distinct compositional banding with light-colored granitic parts, called leucosome, and dark-colored mafic-rich parts, called melanosome, is a migmatite. These features are formed by the partial melting of the rock under extreme high-grade metamorphic conditions. The leucosome represents the crystallized melt, while the melanosome is the residual solid. Migmatites provide a visual record of the transition between high-grade metamorphic rocks and the generation of new granitic magmas in the crust.

225. (A) Both A and R are true and R is the correct explanation of A
Charnockites are granitic rocks characterized by the presence of orthopyroxene, indicating they formed under high-temperature and anhydrous granulite-facies conditions. This lack of hydrous minerals like biotite or hornblende suggests they are products of dry" metamorphism. These conditions are typically found in the deep crust where water is scarce. Their mineralogy and composition make them critical indicators of the thermal and fluid history of ancient, deeply buried continental shields and mobile belts.

226. (A) internal processes; external material addition
The primary difference between magmatic differentiation and assimilation lies in the source of the compositional change. Differentiation involves internal processes within the magma body, such as fractional crystallization or liquid immiscibility, where the magma evolves as it cools. In contrast, assimilation involves the external addition of material as the magma incorporates and melts pieces of the surrounding country rock. Both processes can significantly alter the final composition of the resulting igneous rocks.

227. (C) $P + F = C + 2$
Gibbs' Phase Rule is a fundamental thermodynamic equation used to determine the stability of phases in a system at equilibrium. It relates the number of phases (P), degrees of freedom (F), and chemical components (C). In a general system, the rule is expressed as P plus F equals C plus two. This allows petrologists to calculate how many variables, like temperature and pressure, can be changed without altering the number of phases present in the rock.

228. (D) Anorthosite
In the IUGS classification for plutonic rocks, anorthosite is a rock that is composed of more than ninety percent plagioclase feldspar. These rocks are essentially monomineralic and are characterized by their light color and high calcium content. Anorthosites are significant because they often form the major part of ancient layered mafic intrusions and make up large portions of the Earth's early crust, as well as the highlands of the Moon.

229. (C) Porphyritic
A rock texture featuring euhedral, well-formed phenocrysts embedded in an aphanitic or fine-grained groundmass is described as porphyritic. This texture records a two-stage cooling history. The phenocrysts formed slowly at depth, allowing for their large size and regular shapes. The surrounding groundmass then formed during a subsequent period of much more rapid cooling, often as the magma moved closer to the

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276. (A) Both Statement I and Statement II are true
Slaty cleavage is a prominent type of metamorphic foliation found in low-grade rocks like slate, caused by the parallel alignment of very fine-grained minerals under directed pressure. Hornfelsic texture, on the other hand, is typically non-foliated and granular. This texture develops during contact metamorphism where heat is the dominant agent and there is no significant directed stress to cause mineral alignment. Both statements accurately describe key structural features and textures found in different metamorphic environments.

277. (A) lowest temperature and pressure
The zeolite facies represents the lowest temperature and pressure conditions within the spectrum of metamorphism. It marks the transition between diagenesis and true metamorphism. Zeolite minerals typically form from the alteration of volcanic glass and other minerals in deep sedimentary basins or through low-temperature hydrothermal activity. These conditions generally occur at temperatures below two hundred degrees Celsius, representing the earliest stage of mineralogical change during the burial of crustal rocks.

278. (D) Propanation
Fenitization, greisenization, and silicification are all well-known and common types of metasomatism, each involving significant chemical changes to a rock driven by hydrothermal fluids. These processes introduce or remove specific elements, resulting in specialized mineral assemblages. Propanation is not a recognized geological or metasomatic term. Understanding the different varieties of metasomatism is essential for identifying ancient fluid flow pathways and the formation of various types of economic mineral deposits in the crust.

279. (A) High pressure and high temperature
The transformation of mafic rocks, such as basalt, into eclogite requires conditions of extremely high pressure and high temperature. This process occurs deep within the mantle or at the base of thickened continental crust. Eclogite is composed of garnet and omphacite pyroxene, representing a highly compact and dense mineral assemblage. These high-grade conditions are fundamental for the geological stability of deep lithospheric plates and for understanding the dynamics of subduction zones and crustal thickening.

280. (C) An aluminous sedimentary rock
The protolith for khondalite is interpreted to be an aluminous sedimentary rock, such as an ancient shale or mudstone. These sediments were deposited in basins and subsequently buried to extreme depths, where they underwent high-grade granulite-facies metamorphism. This intense transformation produced the characteristic assemblage of garnet, sillimanite, quartz, and graphite seen today. Khondalites are vital indicators of the presence of ancient supracrustal materials within the deeply metamorphosed foundations of old continental shields.

281. (A) Magmatic differentiation
Magmatic differentiation is the overarching process by which a single parent magma evolves into magmas of different compositions. One of the primary mechanisms for this is the mechanical separation of liquid from crystals, known as fractional crystallization. By physically removing early-formed minerals through settling or filter pressing, the chemistry of the remaining melt is fundamentally changed. This allows for the great diversity of igneous rocks observed in the Earth's crust, from mafic basalts to felsic granites.

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282. (C) Mineralogical composition
The IUGS classification system for igneous rocks is primarily based on their mineralogical composition, specifically the modal proportions of their rock-forming minerals. For plutonic rocks, this involves determining the volume percentages of quartz, alkali feldspar, plagioclase, and feldspathoids using the QAPF diagram. This mineral-based approach provides a consistent and reproducible method for naming rocks that is directly tied to their observed mineral content, rather than their color, grain size, or tectonic setting alone.

283. (B) Whether the majority of crystals are visible to the unaided eye
The boundary between aphanitic and phaneritic textures is defined by the visibility of the majority of the rock's crystals to the unaided eye. Aphanitic rocks are fine-grained, with crystals too small to be seen without magnification, typically indicating

(D) Concretions

28. According to the classification of sediments, what is an argillite?
(A) A rock composed of gravel-sized particles.
(B) A rock composed of clay and silt-sized particles.
(C) A rock composed of sand-sized particles.
(D) A rock formed from the accumulation of organic matter.

29. Match List I with List II.
List I: (Depositional Environment)
P. Aeolian
Q. Glacial
R. Deep Marine
S. Fluvial
List II: (Characteristic Deposit)
1. Turbidites
2. Channel sands and floodplain muds
3. Till (diamictite)
4. Well-sorted, cross-bedded sandstones
(A) P-1, Q-2, R-3, S-4
(B) P-4, Q-3, R-1, S-2
(C) P-4, Q-1, R-3, S-2
(D) P-2, Q-3, R-1, S-4

30. The term for a sedimentary rock containing a significant amount of volcanic glass, crystals, and rock fragments is:
(A) Evaporite
(B) Carbonate
(C) Phosphorite
(D) Volcanoclastic

31. Consider the following statements regarding heavy minerals:
1. They have a specific gravity greater than that of quartz (2.65).
2. Their separation is often done using heavy liquids like bromoform.
3. The ZTR index (Zircon, Tourmaline, Rutile) is a measure of sediment maturity.
Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

32. Which of the following is NOT a mode of sediment transport by a fluid?
(A) Saltation
(B) Lithification
(C) Suspension
(D) Traction

33. What is the defining characteristic of a rudite?
(A) The grains within the rock are predominantly sand-sized particles.
(B) The dominant clasts are larger than 2 mm in diameter.
(C) The rock is primarily composed of carbonate minerals like calcite.
(D) The rock is composed of clay minerals and fine silt-sized particles.

34. A sedimentologist finds a limestone composed of spherical, concentrically layered carbonate grains. What is the most appropriate name for these grains?
(A) Ooids
(B) Peloids
(C) Intraclasts
(D) Bioclasts

35. Given below are two statements:
Statement I : Sedimentary provenance analysis aims to reconstruct the parent rock assemblage, its location, and its tectonic setting.
Statement II : The mineralogical composition of a sandstone is independent of its source rock.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct, but Statement II is incorrect.
(D) Statement I is incorrect, but Statement II is correct.

36. Which one of the following is a key process of diagenesis?
(A) Erosion
(B) Transportation
(C) Weathering
(D) Cementation

37. What type of sedimentary rock is formed from the precipitation of minerals from a solution, such as rock salt or gypsum?
(A) Clastic
(B) Biogenic

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separation can occur through gravity settling, filter pressing, or the growth of crystals along the walls of a magma chamber. By removing specific elements from the melt, fractional crystallization causes the residual magma's composition to change continuously, leading to the formation of a diverse range of igneous rock types.

292. (C) Basalts
The ternary phase diagram for albite, anorthite, and diopside is an essential model for studying the crystallization of basaltic magmas. These three minerals are major components of most mafic rocks. By plotting the evolution of a melt in this system, petrologists can understand the order and proportions in which plagioclase and pyroxene crystallize. This diagram provides critical insights into the phase relationships and mineralogical evolution of the Earth's most abundant volcanic rock type.

293. (A) Derived from a common parent magma or magmatic event
A petrographic province is a geographic region where various igneous rocks are related in space, time, and chemical composition. This relationship implies that the rocks were likely derived from a common parental magma source or were generated during the same major magmatic event. Rocks in such a province are often termed consanguineous. By identifying these provinces, geologists can understand the large-scale magmatic and tectonic history of specific areas of the Earth's crust throughout geological time.

294. (D) The most fractionated end-product of mantle-derived mafic magmas
M-type granites are a relatively rare category thought to be derived as the final, most evolved fractionation product of mantle-derived mafic magmas, particularly in oceanic island arc settings. Unlike S-type granites from sediments or I-type granites from crustal igneous rocks, M-type granites are not formed by the melting of continental crust. Their specialized composition and setting provide important information about the extreme differentiation of mantle melts and the growth of new crustal material.

295. (A) Amba Dongar, Gujarat
The Amba Dongar area in Gujarat is India's most famous locality for its carbonatite complex and the associated process of fenitization. The intrusion of carbonate magmas here led to significant chemical alteration of the surrounding silicate country rocks, creating a characteristic halo of fenite. This site is also important for its fluorite deposits. Amba Dongar provides a world-class example for studying the specialized mineralogy and fluid processes associated with carbonatites and alkaline igneous activity.

296. (C) Dynamic metamorphism
Mylonite is a fine-grained, foliated metamorphic rock that is a classic product of dynamic metamorphism within shear zones. It forms through intense ductile deformation and recrystallization of a host rock as it is subjected to high shear stress at significant depths. This process reduces the grain size and develops a strong parallel fabric. Mylonites are important because they provide a record of the intensity and direction of movement along major crustal and lithospheric boundaries.

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297. (A) Andalusite → Sillimanite → Kyanite
The three polymorphs of aluminum silicate follow a specific sequence of stability as pressure increases at moderate temperatures. Andalusite is stable at the lowest pressures. As pressure increases while temperature is maintained or moderately increased, it transitions into sillimanite. At the highest pressures, kyanite becomes the stable mineral phase. This sequence allows geologists to reconstruct the burial depth and tectonic history of metamorphosed pelitic rocks based on which polymorph is present.

298. (B) Fragments of mafic rock enclosed in a granitic leucosome
Agmatite is a specific type of migmatite structure that has a breccia-like appearance. it consists of angular fragments of the darker, residual mafic rock, known as the melanosome, which are enclosed within a lighter-colored granitic matrix of newly crystallized melt, the leucosome. This structure provides a clear visual demonstration of the physical fragmentation and partial melting that can occur during extreme high-grade regional metamorphism in the middle and lower continental crust.

299. (D) Marble

The metamorphism of basic igneous rocks, like basalt and gabbro, produces a variety of rocks such as greenschist, amphibolite, and eclogite, depending on the metamorphic grade. However, it will not produce marble. Marble is specifically the metamorphic equivalent of carbonate rocks, such as limestone or dolostone. Because basic igneous rocks are dominated by silicates and lack significant calcium carbonate, they cannot be transformed into the carbonate-rich rock that defines a marble.

300. (B) High-temperature, anhydrous granulite-facies conditions

Charnockites are granitic rocks characterized by the presence of orthopyroxene, signifying formation under high-temperature and anhydrous granulite-facies conditions. They typically develop in deep crustal environments where water activity is low, often during intense regional metamorphism. These rocks are fundamental components of ancient shield areas, providing insights into the thermal state and fluid composition of the lower continental crust during major tectonic and magmatic events throughout the Earth's long geological history.

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CHAPTER 05
Sedimentology

1. Which of the following best defines the process of sedimentation?
(A) The physical and chemical breakdown of rocks at the Earth's surface.
(B) The deposition of sediments by agents like water, wind, or ice.
(C) The movement of weathered material from its source area.
(D) The transformation of loose sediment into solid sedimentary rock.

2. Which term refers to the bouncing or skipping of sediment grains along a stream bed?
(A) Saltation
(B) Suspension
(C) Traction
(D) Solution

3. Given below are two statements regarding fluid flow in sedimentation:
Statement I : In laminar flow, fluid particles move in smooth, parallel paths.
Statement II : Turbulent flow is characterized by chaotic and irregular particle movement, which is more effective at eroding and transporting sediment.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct, but Statement II is incorrect.
(D) Statement I is incorrect, but Statement II is correct.

4. Which of the following is NOT considered a primary sedimentary structure?
(A) Cross-bedding
(B) Graded bedding
(C) Mud cracks
(D) Stylolites

5. What is the primary significance of analyzing palaeocurrent indicators?
(A) To determine the absolute age of the sedimentary rock sequence.
(B) To understand the diagenetic history of the sediment post-deposition.
(C) To reconstruct the direction of ancient currents and sediment transport.
(D) To measure the primary porosity and permeability of the lithified rock.

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6. Identify the correct statement regarding the classification of sediments based on grain size.
(A) Arenites are composed of particles significantly larger than 2 mm in diameter.
(B) Rudites consist of gravel-sized clasts, including boulders, cobbles, and pebbles.
(C) Argillites are predominantly composed of sand-sized particles within the matrix.
(D) Silt and clay are the primary components of rudaceous rock types in the field.

7. Match List I with List II.
List I: (Sedimentary Rock)
P. Argillite
Q. Arenite
R. Rudite
S. Siltstone
List II: (Dominant Grain Size)
1. > 2 mm
2. 1/16 mm to 2 mm
3. 1/16 mm to 1/256 mm
4. $< 1/256$ mm
(A) P-4, Q-2, R-1, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-4, Q-3, R-1, S-2
(D) P-2, Q-1, R-4, S-3

8. A sedimentary rock is found to have more than 15% matrix material mixed with sand-sized grains. According to sandstone classification, what is the most appropriate term for this rock?
(A) Greywacke
(B) Arkose
(C) Quartz Arenite

48. A rock composed of angular, gravel-sized clasts that are poorly sorted would be best described as a:
(A) Quartz arenite
(B) Breccia
(C) Shale
(D) Oolitic limestone

49. Which statement best describes the utility of heavy minerals in provenance analysis?
(A) All heavy minerals are equally stable and provide the same specific information.
(B) Different heavy mineral suites can be characteristic of specific source rock types.
(C) Heavy minerals are generally useless because they are rare and difficult to separate.
(D) The color of heavy minerals directly and accurately indicates the age of source rocks.

50. The classification of dolomite is primarily based on:
(A) The size of the dolomite crystals.
(B) The ratio of calcite to dolomite.
(C) The types of fossils present.
(D) The percentage of matrix material.

51. Consider the following statements about sedimentary textures:
1. Sphericity measures how closely a grain's shape approaches a sphere.
2. Roundness describes the smoothness of the corners and edges of a grain.
3. A sediment with high sphericity must also have high roundness.

Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

52. The term that describes the origin of sediments, including the parent rock type and location, is:
(A) Diagenesis
(B) Facies
(C) Taphonomy
(D) Provenance

53. Match List I with List II.
List I: (Sedimentary Structure)
P. Flute Casts
Q. Mud Cracks
R. Stromatolites
S. Hummocky Cross-Stratification
List II: (Formation Environment/Mechanism)
1. Tidal flat, microbial activity
2. Subaerial exposure and desiccation
3. Scour by a turbulent current
4. Storm wave action on the shelf
(A) P-3, Q-2, R-1, S-4
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-4, R-1, S-2
(D) P-2, Q-1, R-4, S-3

54. What type of provenance is indicated by a sandstone rich in volcanic rock fragments, plagioclase, and pyroxene?
(A) Craton interior
(B) Magmatic arc
(C) Recycled orogen
(D) Metamorphic belt

55. The formation of evaporite minerals like halite and gypsum occurs in which type of environment?
(A) A high-latitude glacial environment.
(B) A deep marine trench with high sediment input.
(C) A rapidly flowing mountain stream.
(D) An arid or semi-arid basin with high evaporation rates.

56. Given below are two statements:
Statement I : Lithification is the comprehensive term for all processes that convert unconsolidated sediment into sedimentary rock.
Statement II : Compaction and cementation are two of the most important processes in lithification.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct, but Statement II is incorrect.
(D) Statement I is incorrect, but Statement II is correct.

57. Which of the following is an example of a chemical sedimentary rock?
(A) Conglomerate
(B) Sandstone

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(C) II, I, IV, III
(D) IV, II, I, III

18. What does the term provenance" in sedimentology refer to?
(A) The original source area and rock types from which the sediment was derived.
(B) The determined absolute age of the sedimentary rock within the sequence.
(C) The specific environment in which the sediment was originally deposited.
(D) The physical process of cementation and compaction occurring during burial.

19. Which of the following minerals is most stable in weathering environments and thus a reliable indicator in provenance studies?
(A) Olivine
(B) Pyroxene
(C) Zircon
(D) Calcite

20. A limestone classification system is based on the depositional texture, particularly the proportion of grains to mud matrix and whether the grains are mud-supported or grain-supported. Which classification scheme is this?
(A) Folk's classification
(B) Dott's classification
(C) Wentworth's scale
(D) Dunham's classification

21. Given below are two statements:
Statement I : Diagenesis includes all physical and chemical changes that occur in sediments after deposition but before metamorphism.
Statement II : Weathering at the Earth's surface is considered a diagenetic process.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct, but Statement II is incorrect.
(D) Statement I is incorrect, but Statement II is correct.

22. The rolling and sliding of the coarsest sediment particles along a channel floor is known as:
(A) Suspension
(B) Traction
(C) Saltation
(D) Solution load

23. Which of the following depositional environments is NOT a continental environment?
(A) Fluvial
(B) Lacustrine
(C) Glacial
(D) Deltaic

24. A sedimentary rock composed primarily of shell fragments would be classified as what type of sedimentary rock?
(A) Organic (Biochemical)
(B) Clastic
(C) Chemical
(D) Volcanoclastic

25. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : Cross-bedding is a valuable palaeocurrent indicator.
Reason (R) : The inclined foreset beds of a cross-bed dip in the direction of the ancient current flow.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

26. Granulometric analysis is performed on a clastic sediment sample. What is the primary objective of this analysis?
(A) To measure the distribution of grain sizes within the sample.
(B) To identify the specific mineral composition of the framework grains.
(C) To determine the absolute age of the sediment through dating methods.
(D) To study the diagenetic alterations occurring within the rock sample.

27. Which of the following is considered a secondary sedimentary structure, formed after deposition?
(A) Ripple marks
(B) Graded bedding
(C) Lamination

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rapid extrusive cooling. Phaneritic rocks have large, visible crystals, signifying slow intrusive cooling at depth. This simple textural distinction is one of the most fundamental observations used to categorize igneous rocks in the field.

284. (B) P-2, Q-4, R-1, S-3
Each metamorphic facies is defined by its specific range of pressure and temperature conditions. Blueschist facies occurs at high pressure and low temperature, while granulite facies represents high pressure and high temperature. Hornfels facies is characteristic of low pressure and high temperature environments, typical of contact metamorphism. Greenschist facies involves low-to-medium pressure and temperature. Matching these facies to their P-T conditions is essential for reconstructing the tectonic and thermal history of metamorphic belts.

285. (C) Stromatic
A layered structure in a migmatite is specifically described as stromatic. This texture consists of alternating thin, parallel bands of light-colored leucosome and dark-colored melanosome. These bands often follow the pre-existing foliation of the parent metamorphic rock. The stromatic structure is one of the most common and visually striking features of migmatites, providing direct evidence of the segregation of partial melt into layers during extreme high-grade metamorphic events in the crust.

286. (D) Diorite
Diorite is the plutonic equivalent of an andesite. Both rocks share an intermediate chemical composition, with silica content typically between fifty-two and sixty-three percent. They are both characterized by the presence of plagioclase feldspar and ferromagnesian minerals like hornblende. While andesite is fine-grained and volcanic, forming from rapid cooling at the surface, diorite is coarse-grained and intrusive, forming from the slow cooling of the same magma type deep underground.

287. (B) Heat
Heat is the dominant agent of metamorphism in the formation of contact aureoles. These zones surround igneous intrusions where the intense thermal energy from the magma body causes the adjacent country rock to bake and recrystallize. Because contact metamorphism typically occurs at relatively shallow depths where pressure is low, the resulting transformation is driven almost entirely by the temperature gradient, leading to the formation of non-foliated rocks like hornfels and marble.

288. (B) Isochemical
A metamorphic process is described as isochemical when there is little or no significant change in the bulk chemical composition of the rock, excluding the loss of volatile components like water and carbon dioxide. During isochemical metamorphism, the pre-existing minerals simply react and reorganize into new mineral phases that are stable under the new pressure and temperature conditions. Most regional and prograde metamorphism follows this pattern, allowing geologists to trace the original chemical signature of the protolith.

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289. (A) I and II only
The metamorphism of pure limestone produces marble, where calcite crystals simply grow larger. If the limestone is impure and contains silica-rich minerals like quartz or clay, the calcium carbonate will react with them to form a variety of calc-silicate minerals such as wollastonite, garnet, or pyroxene. However, because carbonate rocks have relatively simple chemistry, they do not produce the wide variety of index minerals that are seen in more complex rocks like pelites.

290. (A) Both A and R are true and R is the correct explanation of A
Migmatites are typically found in the core of high-grade metamorphic terrains where the highest temperatures were reached. This is because their formation requires temperatures that are sufficient to initiate the partial melting of the rock, a process known as anatexis. This transition occurs at the upper limit of metamorphism, just before the rock would completely melt to form a new magma body. Their presence provides vital evidence of extreme crustal heating and tectonic intensity.

291. (B) Fractional crystallization
Fractional crystallization is the process where early-formed minerals are physically separated from the magma, preventing them from reacting further with the remaining liquid. This

(C) Evaporite
(D) Pyroclastic

38. What is the primary significance of analyzing palaeocurrent indicators?
(A) To determine the absolute age of the sedimentary rock.
(B) To understand the diagenetic history of the sediment.
(C) To reconstruct the direction of ancient currents and sediment transport.
(D) To measure the porosity and permeability of the rock.

39. Identify the correct pair representing a depositional environment and its typical energy level.
(A) Deep marine abyssal plain - High energy
(B) Aeolian dune field - Low energy
(C) Lacustrine (lake center) - High energy
(D) Glacial outwash plain - High energy

40. Arrange the following clastic particles in decreasing order of their size according to the Wentworth scale.
I. Cobble
II. Sand
III. Silt
IV. Pebble
(A) I, IV, II, III
(B) I, II, IV, III
(C) II, III, I, IV
(D) IV, I, II, III

41. A bed that shows a progressive decrease in grain size from bottom to top is described as:
(A) Reverse graded
(B) Cross-bedded
(C) Normally graded
(D) Laminated

42. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : The mineral stability series (Goldich series) is the inverse of Bowen's reaction series.
Reason (R) : Minerals like olivine that crystallize at high temperatures are chemically less stable at the Earth's surface compared to minerals like quartz that crystallize at lower temperatures.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

43. Which of the following is an example of a transitional depositional environment?
(A) Alluvial fan
(B) Deep-sea fan
(C) Desert
(D) Estuary

44. The term 'arenite' in sedimentary rock classification implies that the rock is:
(A) A consolidated deposit of gravel-sized clasts.
(B) A sandstone with less than 15% silt-clay matrix.
(C) A mudrock with high fissility and clay content.
(D) A limestone composed predominantly of fossil remains.

45. The physical compaction of sand during burial primarily results in:
(A) A significant increase in primary porosity within the unit.
(B) The rapid formation of authigenic minerals in pore spaces.
(C) A re-orientation of grains leading to a decrease in porosity.
(D) The complete dissolution of all quartz grains in the rock.

46. Which of the following is NOT a common cement type in sandstones?
(A) Calcite
(B) Silica (Quartz)
(C) Hematite
(D) Olivine

47. In the context of fluid flow, Reynolds number is a dimensionless quantity used to predict:
(A) The transition from laminar to turbulent flow.
(B) The settling velocity of a particle.
(C) The porosity of a sediment.
(D) The mineralogical maturity of a sandstone.

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(D) Litharenite

9. Which of the following statements about textures of sedimentary rocks is incorrect?
(A) Texture refers to the size, shape, and arrangement of constituent grains.
(B) Well-sorted sediments indicate a consistent energy level in the depositional environment.
(C) Angular grains suggest a long distance of transport from the source.
(D) Grain fabric describes the orientation and packing of the sedimentary particles.

10. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : Stoke's Law is fundamental to understanding the settling of fine particles in a fluid.
Reason (R) : The law states that the terminal settling velocity of a spherical particle is directly proportional to the square of its radius and the difference in density between the particle and the fluid.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

11. A geologist observes a sandstone outcrop and wants to determine its provenance. Which of the following analytical steps would be most useful?
(A) Measuring the strike and dip of the bedding planes.
(B) Analyzing the fossil content within the sandstone layers.
(C) Conducting a granulometric analysis to determine grain size distribution.
(D) Separating and identifying the suite of heavy minerals.

12. Consider the following statements about depositional environments:
1. Continental environments include fluvial, aeolian, and lacustrine systems.
2. Transitional environments are interfaces between marine and continental settings, such as deltas and lagoons.
3. Deep marine environments are characterized by high-energy conditions and coarse-grained deposits.

Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

13. What is the process by which loose, unconsolidated sediment is converted into solid sedimentary rock?
(A) Provenance
(B) Sedimentation
(C) Lithification
(D) Transport

14. Identify the incorrect pair of sedimentary structure and its typical formation process.
(A) Graded Bedding - Settling of particles from a turbidity current.
(B) Cross-Bedding - Migration of ripples or dunes.
(C) Raindrop Imprints - Impact of raindrops on a soft mud surface.
(D) Mud Cracks - Continuous submergence under water.

15. In the context of Stoke's Law, what happens to the settling velocity of a particle if the viscosity of the fluid increases, assuming all other factors remain constant?
(A) The velocity decreases.
(B) The velocity increases.
(C) The velocity remains unchanged.
(D) The velocity becomes zero.

16. Which of the following is an example of an organic sedimentary structure?
(A) Flute cast
(B) Stromatolite
(C) Concretion
(D) Load cast

17. Arrange the following processes of lithification in their most likely chronological sequence.
I. Compaction
II. Deposition
III. Cementation
IV. Burial
(A) II, IV, I, III
(B) I, II, III, IV

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(C) Chert
(D) Shale

58. Identify the incorrect statement regarding modes of sediment transport.
(A) Saltation is the primary mode of transport for large boulders in a river.
(B) Bedload consists of particles moving along the bottom by traction or saltation.
(C) Dissolved load refers to ions transported in solution.
(D) The finest particles like clay and fine silt are typically carried in suspension.

59. The primary components used in Folk's classification of limestones are:
(A) Average grain size and total matrix percentage.
(B) Primary depositional texture and grain fabric.
(C) Individual crystal size and measured porosity.
(D) Allochems and orthochems (micrite/sparite).

60. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : Aeolian deposits are typically very well sorted.
Reason (R) : Wind is a highly selective transport agent, capable of moving only a narrow range of particle sizes for a given velocity.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

61. Which of the following best describes the texture of a rock with a wide range of grain sizes?
(A) Well-sorted
(B) Positively skewed
(C) Poorly sorted
(D) Negatively skewed

62. The process of separating heavy minerals from a sand sample using a liquid with a high specific gravity is an example of:
(A) Granulometric analysis
(B) Petrographic analysis
(C) X-ray diffraction
(D) Density separation

63. Which depositional environment is characterized by the accumulation of till, a poorly sorted mixture of clay, sand, gravel, and boulders?
(A) Glacial
(B) Fluvial
(C) Lacustrine
(D) Deltaic

64. What is the genetic significance of finding highly angular clasts in a sedimentary rock like a breccia?
(A) It suggests a very long and abrasive transport history.
(B) It implies minimal transport from a nearby source area.
(C) It indicates deposition far from the sediment source.
(D) It points to a deep marine depositional environment.

65. Arrange the following environments in a typical seaward progression from the coast.
I. Neritic (Shallow Marine)
II. Beach (Transitional)
III. Bathyal (Deep Marine)
IV. Lagoon (Transitional)
(A) IV, II, I, III
(B) II, IV, I, III
(C) I, II, III, IV
(D) II, I, IV, III

66. The term 'argillaceous' refers to a sedimentary rock that is rich in:
(A) Clay minerals
(B) Sand
(C) Carbonates
(D) Gravel

67. Primary sedimentary structures are those that form:
(A) Long after deposition due to chemical changes.
(B) As a result of tectonic deformation.
(C) During or very shortly after deposition.
(D) Due to metamorphic processes.

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68. In sandstone classification, an Arkose is defined as a sandstone containing:
(A) More than 95% quartz grains with very little matrix.
(B) A significant amount of rock fragments within the framework.
(C) More than 15% clay matrix interspersed between the grains.
(D) A significant amount of feldspar (typically >25%).

69. Which of the following is a key factor controlling the process of sedimentation?
(A) The magnetic polarity of the Earth.
(B) The color of the sediment grains.
(C) The velocity of the transporting fluid.
(D) The age of the underlying basement rock.

70. Consider the following statements:
1. Flute casts are erosional structures formed on the base of a bed.
2. Flute casts are excellent indicators of palaeocurrent direction.
3. Flute casts are formed by subaerial desiccation.

Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

71. The study of the distribution of grain sizes in a sediment is called:
(A) Provenance analysis
(B) Diagenetic study
(C) Palaeocurrent analysis
(D) Granulometry

72. Match List I with List II.
List I: (Clastic Rock)
P. Conglomerate
Q. Breccia
R. Sandstone
S. Shale
List II: (Defining Characteristic)
1. Sand-sized grains
2. Fissile, clay/silt-sized grains
3. Rounded gravel-sized clasts
4. Angular gravel-sized clasts
(A) P-4, Q-3, R-1, S-2
(B) P-3, Q-4, R-1, S-2
(C) P-3, Q-4, R-2, S-1
(D) P-1, Q-2, R-3, S-4

73. The concept that less stable minerals are weathered and removed during transport, leading to a sediment enriched in more stable minerals, is central to the idea of:
(A) Diagenesis
(B) Palaeocurrents
(C) Sedimentary maturity
(D) Lithification

74. Given below are two statements:
Statement I : Dolostone (or dolomite rock) is a carbonate rock composed predominantly of the mineral dolomite.
Statement II : Most dolostones are believed to form through the primary precipitation of dolomite crystals directly from seawater.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct, but Statement II is incorrect.
(D) Statement I is incorrect, but Statement II is correct.

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75. In Stoke's Law, $V = \frac{2}{9}\frac{(\rho_p - \rho_f)}{\mu} gr^2$, the term '$\mu$' represents:
(A) The density of the particle (ρ_p)
(B) The radius of the particle (r)
(C) The acceleration due to gravity (g)
(D) The dynamic viscosity of the fluid

76. All of the following are considered depositional environments EXCEPT:
(A) A river channel
(B) A magma chamber
(C) A desert dune field
(D) A deep-sea floor

77. Which of these structures is a result of soft-sediment deformation soon after deposition?
(A) Cross-bedding
(B) Stylolite
(C) Load cast
(D) Vug

78. A sandstone composed of more than 25% lithic fragments (rock fragments) is best termed a:

(A) Quartz arenite
(B) Arkose
(C) Greywacke
(D) Litharenite

79. The term 'fissility' is most commonly associated with which sedimentary rock?
(A) Shale
(B) Conglomerate
(C) Sandstone
(D) Limestone

80. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : Turbidites, common in deep marine settings, typically exhibit graded bedding.
Reason (R) : They are deposited from turbidity currents, which are dense, sediment-laden flows where coarser grains settle out first, followed by progressively finer grains as the current wanes.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

81. A student is analyzing a sediment sample and finds it is composed of 70% sand, 20% silt, and 10% clay. What is the most appropriate name for this unconsolidated sediment?
(A) Silt
(B) Sand
(C) Clay
(D) Gravel

82. What is the main utility of the ZTR index in provenance analysis?
(A) To act as an index of mineralogical maturity of the sediment.
(B) To determine the absolute age of the sediment through dating.
(C) To measure the degree of sorting within the clastic sample.
(D) To identify the specific depositional environment of the rock.

83. Which of the following describes a continental depositional environment?
(A) A shallow sea shelf
(B) An estuary where a river meets the sea
(C) A desert playa lake
(D) A carbonate reef platform

84. Identify the process that is NOT part of diagenesis.
(A) Compaction
(B) Cementation
(C) Dissolution
(D) Transport

85. In Dunham's classification of limestones, what is the term for a mud-supported carbonate rock containing more than 10% grains?
(A) Mudstone
(B) Packstone
(C) Wackestone
(D) Grainstone

86. The study of layered rocks (strata), particularly their sequence, correlation, and interpretation, is known as:
(A) Petrology
(B) Stratigraphy
(C) Sedimentology
(D) Geochronology

87. Which of the following is an example of an organic sedimentary rock?
(A) Breccia
(B) Rock Salt
(C) Sandstone
(D) Coal

88. Consider the following statements about palaeocurrent analysis:
1. The orientation of ripple marks can indicate current direction.
2. The direction of imbricated (overlapping) pebbles in a conglomerate points upstream.
3. Palaeocurrent data is not useful for basin analysis.
Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

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(A) A surface of erosion or non-deposition, indicating a gap in the geologic record.
(B) A period of continuous and rapid deposition of sediments within a stable basin.
(C) A specific layer of sedimentary rock that is exceptionally rich in index fossils.
(D) A zone of intense chemical cementation that occurs during the deep burial stage.

128. What is the most common mineral found in sandstones globally?
(A) Feldspar
(B) Quartz
(C) Calcite
(D) Halite

129. The term for the original pore space between grains in a sediment at the time of deposition is:
(A) Secondary porosity
(B) Primary porosity
(C) Fracture porosity
(D) Vuggy porosity

130. A geologist identifies a sedimentary rock made almost entirely of the mineral gypsum. This rock is best classified as:
(A) An evaporite
(B) A volcanoclastic rock
(C) A conglomerate
(D) A shale

131. Which of the following best explains the formation of graded bedding?
(A) Seasonal changes in a low-energy, deep-water lake environment.
(B) The migration of sand dunes across an arid desert environment.
(C) Gradual settling of sediment from a waning current (e.g., turbidity).
(D) The back-and-forth motion of waves on a high-energy beach front.

132. The process of separating heavy minerals is crucial for provenance studies because:
(A) Heavy minerals are the most abundant minerals in all sandstones.
(B) Heavy minerals are extremely unstable and indicate short transport.
(C) The color of heavy minerals directly gives the age of the sediment.
(D) Heavy mineral suites are often diagnostic of specific source rock types.

133. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : In a river system, sediment grain size generally decreases downstream.
Reason (R) : As the transport distance increases, abrasive action reduces particle size, and the decreasing river gradient allows only finer particles to remain in transport.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

134. Which of the following is a characteristic of sediments deposited in a deltaic environment?
(A) Uniformly coarse gravel deposits formed in high-energy mountain stream channels.
(B) A complex inter-fingering of fluvial channel sands, marsh peats, and marine muds.
(C) A thick, unstratified deposit of glacial till found at the front of a glacier.
(D) Exclusively chemical precipitates like rock salt and gypsum from restricted seas.

135. The term 'diagenesis' encompasses all changes to a sediment under conditions of:
(A) High temperature and pressure, leading to metamorphism.
(B) Surface exposure, also known as weathering.
(C) Erosion and transport prior to deposition.
(D) Low temperature and pressure, post-deposition but pre-metamorphism.

136. A sedimentary rock composed of 40% quartz, 35% feldspar, and 25% mica and rock fragments would be best described as compositionally:
(A) Immature
(B) Mature
(C) Supermature
(D) Submature

137. Which of the following is a primary sedimentary structure?
(A) Stylolite
(B) Concretion
(C) Ripple marks

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(B) A preserved shell
(C) A dinosaur bone
(D) A stromatolite

99. A lagoon is best described as which type of depositional environment?
(A) A deep marine environment located well below the photic zone with minimal sediment.
(B) A continental environment dominated by wind action and the formation of large dunes.
(C) A transitional environment with shallow water separated from the sea by a barrier.
(D) A glacial environment situated at the foot of a melting ice sheet and moraine complex.

100. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : Heavy minerals are powerful tools for provenance analysis.
Reason (R) : Assemblages of heavy minerals can be diagnostic of particular source rock terranes.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

101. A geologist is examining a limestone that lacks a muddy matrix and is composed of grains that support each other. According to Dunham's classification, what is this rock called?
(A) Mudstone
(B) Wackestone
(C) Grainstone
(D) Packstone

102. Which of the following is NOT a process of physical weathering that generates sediment?
(A) Frost wedging
(B) Dissolution
(C) Abrasion
(D) Thermal expansion

103. The term 'volcanoclastic sediment' refers to:
(A) Sediments formed by the evaporation of saline water.
(B) Sediments derived from the weathering of metamorphic rocks.
(C) Sediments composed entirely of fossil fragments.
(D) Sediments composed of fragments of volcanic origin.

104. What is the genetic significance of sedimentary texture?
(A) It reflects the transport mechanism, distance of transport, and depositional energy.
(B) It provides direct and accurate information about the absolute age of the rock unit.
(C) It determines the magnetic polarity of the rock at the time of its initial formation.
(D) It exclusively indicates the mineralogical composition of the source rock region.

105. Consider the following statements regarding sedimentary rock classification:
1. Clastic rocks are classified primarily on particle size.
2. Chemical rocks are classified based on their mineral composition.
3. Organic rocks are composed of the remains of living organisms.

Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

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106. In Folk's classification of limestones, what does the term 'micrite' refer to?
(A) The fine-grained carbonate mud matrix (<4 microns).
(B) The framework grains like ooids or bioclasts.
(C) The sparry calcite cement that fills pores.
(D) Recrystallized dolomite crystals.

107. Which of the following is an example of a sole mark, a type of primary sedimentary structure found on the bottom surface of a bed?
(A) Mud crack
(B) Raindrop imprint
(C) Ripple mark
(D) Flute cast

108. The concept of 'provenance' includes understanding all of the following aspects of the source area EXCEPT:

89. A sedimentary rock that is composed of more than 50% carbonate minerals is broadly classified as a:
(A) Sandstone
(B) Mudrock
(C) Limestone or Dolostone
(D) Evaporite

90. Arrange the following common rock-forming minerals in order of increasing stability at the Earth's surface (from least stable to most stable).
I. Quartz
II. Olivine
III. Pyroxene
IV. Muscovite Mica
(A) I, IV, III, II
(B) II, III, IV, I
(C) III, II, I, IV
(D) IV, I, II, III

91. What is the cause-and-effect relationship between fluid velocity and sediment transport?
(A) A decrease in fluid velocity causes immediate erosion and transport of larger particles.
(B) An increase in fluid velocity causes widespread deposition of fine-grained sediment.
(C) Fluid velocity has no significant effect on the sediment transport or deposition rate.
(D) A decrease in fluid velocity below a critical threshold for a particle causes deposition.

92. The origin of sediments can be broadly categorized as:
(A) Only from pre-existing igneous rocks.
(B) Terrigenous (from land), biogenic (from organisms), and chemical (precipitates).
(C) Only from volcanic eruptions.
(D) Only from the deep ocean floor.

93. Given below are two statements:
Statement I : The term texture" in sedimentary rocks refers to large-scale features like bedding and ripple marks.
Statement II : The term structure" in sedimentary rocks refers to the size, shape, and arrangement of individual grains.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct, but Statement II is incorrect.
(D) Statement I is incorrect, but Statement II is correct.

94. Which of the following is a characteristic feature of a beach environment?
(A) Poorly sorted glacial till composed of clay, sand, and large boulders.
(B) Deep-water turbidite sequences formed by high-density gravity flows.
(C) Evaporite deposits like halite and gypsum formed in restricted basins.
(D) Well-sorted sand, often with parallel lamination or low-angle cross-bedding.

95. The replacement of primary carbonate minerals with dolomite is a common diagenetic process known as:
(A) Dolomitization
(B) Cementation
(C) Compaction
(D) Silicification

96. Match List I with List II.
List I: (Sandstone Type)
P. Quartz Arenite
Q. Arkose
R. Litharenite
S. Greywacke
List II: (Key Compositional Feature)
1. >15% clay matrix
2. >25% feldspar
3. >25% unstable rock fragments
4. >95% quartz grains
(A) P-1, Q-3, R-2, S-4
(B) P-4, Q-1, R-3, S-2
(C) P-4, Q-2, R-3, S-1
(D) P-2, Q-4, R-1, S-3

97. The term 'rudaceous' is synonymous with which sediment size class?
(A) Psephitic (gravel)
(B) Argillaceous (clay/silt)
(C) Arenaceous (sand)
(D) Carbonaceous (organic)

98. Which of these is a trace fossil, an example of an organic sedimentary structure?
(A) A burrow or trackway

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(A) The size of the clasts.
(B) The mineral composition of the clasts.
(C) The angularity of the clasts.
(D) The type of cement.

118. Which of the following depositional environments is transitional?
(A) Fluvial
(B) Delta
(C) Eolian
(D) Lacustrine

119. A key aspect of granulometric analysis involves plotting data on a histogram or cumulative frequency curve to determine statistical parameters like:
(A) Mean, sorting, skewness, and kurtosis.
(B) Porosity, permeability, and fluid saturation.
(C) Mineral stability and source rock type.
(D) Palaeocurrent direction and flow velocity.

120. Match List I with List II.
List I: (Term)
P. Arenite
Q. Rudite
R. Argillite
S. Lithification
List II: (Definition)
1. Consolidated rock of gravel-sized particles
2. Processes that turn sediment into rock
3. Consolidated rock of sand-sized particles
4. Consolidated rock of mud-sized particles
(A) P-3, Q-1, R-4, S-2
(B) P-1, Q-3, R-4, S-2
(C) P-3, Q-1, R-2, S-4
(D) P-4, Q-2, R-1, S-3

121. The dissolution of unstable grains like feldspar during diagenesis leads to the formation of:
(A) Primary porosity
(B) Intergranular cement
(C) Secondary porosity
(D) Stylolites

122. Which one of the following is NOT a type of sedimentary provenance?
(A) Diagenetic Overprint
(B) Craton Interior
(C) Recycled Orogen
(D) Magmatic Arc

123. The classification of sandstone into types like quartz arenite, arkose, and litharenite is based on the relative proportions of:
(A) Calcite, Dolomite, and Ankerite.
(B) Silt, Clay, and Sand.
(C) Heavy minerals, light minerals, and matrix.
(D) Quartz, Feldspar, and Lithic fragments.

124. The presence of abundant, delicate, and well-preserved fossils in a fine-grained shale suggests what type of depositional environment?
(A) A high-energy, turbulent river channel.
(B) A low-energy, quiet-water environment with rapid burial.
(C) A wind-blown desert environment.
(D) The area directly in front of a melting glacier.

125. Given below are two statements:
Statement I : Bedding planes in sedimentary rocks represent surfaces of non-deposition or changes in depositional conditions.
Statement II : Bedding is a secondary structure formed during diagenesis.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct, but Statement II is incorrect.
(D) Statement I is incorrect, but Statement II is correct.

126. Consider the following statements about sediment transport:
1. Stoke's Law accurately describes the settling of large, irregularly shaped cobbles in a turbulent river.
2. Suspension is the dominant transport mechanism for clay particles in most aquatic systems.
3. Traction involves the continuous rolling or sliding of grains along the bed.
Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

127. In a sedimentary sequence, an unconformity represents:

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correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct, but Statement II is incorrect.
(D) Statement I is incorrect, but Statement II is correct.

148. The primary origin of sediments is the:
(A) Mantle of the Earth.
(B) Metamorphism of existing rocks.
(C) Crystallization of magma at depth.
(D) Weathering and erosion of pre-existing rocks.

149. In a depositional sequence, what does a change from coarse-grained sandstones at the bottom to fine-grained shales at the top (a fining-upward sequence) typically indicate?
(A) An increase in the energy of the depositional environment.
(B) A marine regression (sea-level fall).
(C) A marine transgression (sea-level rise).
(D) A period of intense volcanic activity.

150. Consider the following statements about evaporites:
1. They are clastic sedimentary rocks classified by grain size.
2. They form by the precipitation of minerals from saline water as it evaporates.
3. Gypsum and halite are common examples of evaporite minerals.

Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

151. What is the main reason for the significance of palaeocurrents in assessing the quality of a hydrocarbon reservoir?
(A) They indicate the thermal maturity and hydrocarbon potential of the reservoir rock.
(B) They help predict the orientation and connectivity of sand bodies that form reservoirs.
(C) They directly and accurately measure the primary and secondary porosity of the rock.
(D) They determine the geometry and trend of sand bodies, which control reservoir continuity.

152. Which of these is a secondary sedimentary structure formed by pressure solution after deep burial?
(A) Stylolites
(B) Graded bedding
(C) Cross-bedding
(D) Mud cracks

153. The term that describes the overall characteristics of a sedimentary rock body, reflecting its depositional environment, is:
(A) Provenance
(B) Diagenesis
(C) Facies
(D) Texture

154. A clastic rock composed of rounded pebbles and cobbles cemented together is called:
(A) Conglomerate
(B) Shale
(C) Sandstone
(D) Breccia

155. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : The separation of heavy minerals is a standard procedure in provenance studies.
Reason (R) : Heavy minerals like zircon, tourmaline, and rutile are highly resistant to weathering and can survive multiple sedimentary cycles.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

156. In the classification of common sediments, 'argillites' refer to rocks predominantly composed of:
(A) Large gravel-sized clasts.
(B) Silt and clay-sized particles.
(C) Medium sand-sized grains.
(D) Solid carbonate bioclasts.

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(D) Joint

138. The main difference between a 'mudstone' and a 'shale' is that:
(A) Shale is fissile (tends to split into thin layers), while mudstone is blocky.
(B) Mudstone is coarser-grained than shale.
(C) Shale is composed of carbonate, while mudstone is siliciclastic.
(D) Mudstone is a metamorphic rock, while shale is sedimentary.

139. What type of sedimentary provenance is characterized by sediment derived from the uplift and erosion of pre-existing sedimentary and low-grade metamorphic rocks?
(A) Craton interior
(B) Magmatic arc
(C) Rift basin
(D) Recycled orogen

140. Arrange the following grain sizes in ascending order (smallest to largest).
I. Sand
II. Clay
III. Cobble
IV. Silt
(A) II, IV, I, III
(B) IV, II, I, III
(C) II, I, IV, III
(D) I, II, III, IV

141. The classification of limestone by R.L. Folk uses the combination of allochem type and the nature of the material filling the space between them. Which pair represents the two types of filling material in this classification?
(A) Grains and Matrix
(B) Sand and Silt
(C) Micrite and Sparite
(D) Calcite and Dolomite

142. If a granulometric analysis reveals that a sand sample is very well sorted and has a symmetrical grain size distribution, what can be inferred about the depositional process?
(A) A chaotic, high-energy event like a landslide or debris flow sequence.
(B) Rapid deposition directly from melting ice with no secondary reworking.
(C) Rapid deposition in a low-energy, stagnant water body with little flow.
(D) A prolonged and consistent process, such as wind or beach wave activity.

143. Which of the following processes leads to a reduction in the porosity of a sandstone during burial?
(A) Mechanical compaction of grains
(B) Dissolution of cement
(C) Formation of fractures
(D) Dissolution of unstable grains

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144. Identify the incorrect pair of a sedimentary environment and a characteristic feature.
(A) Fluvial - Point bars
(B) Glacial - Varves
(C) Eolian - Loess deposits
(D) Deep Marine - Mud cracks

145. Match List I with List II.
List I: (Diagenetic Process)
P. Compaction
Q. Cementation
R. Dissolution
S. Replacement
List II: (Description)
1. Precipitation of minerals in pore spaces
2. Removal of mineral matter by fluids
3. One mineral dissolving and another taking its place
4. Reduction of bulk volume due to overburden pressure
(A) P-1, Q-4, R-2, S-3
(B) P-4, Q-1, R-3, S-2
(C) P-4, Q-1, R-2, S-3
(D) P-2, Q-3, R-1, S-4

146. A sandstone with over 95% stable quartz grains is known as a:
(A) Quartz Arenite
(B) Greywacke
(C) Arkose
(D) Litharenite

147. Given below are two statements:
Statement I : The shape of a particle (sphericity and roundness) provides clues about its transport history.
Statement II : Highly angular grains are indicative of long and abrasive transport.
(A) Both Statement I and Statement II are

(A) The composition of the source rocks.
(B) The diagenetic history of the deposited sediment.
(C) The location and tectonic setting of the source area.
(D) The climatic and topographic conditions of the source area.

109. Given below are two statements:
Statement I : Marine environments are broadly divided into shallow and deep marine settings.
Statement II : The continental shelf is considered a deep marine environment.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct, but Statement II is incorrect.
(D) Statement I is incorrect, but Statement II is correct.

110. The formation of a conglomerate, a rock with rounded gravel-sized clasts, implies what about its transport history?
(A) No transport has occurred from the source area.
(B) Deposition directly from melting ice with no water.
(C) Formation in a low-energy, quiet water environment.
(D) Transport over a distance by water, rounding clasts.

111. Which sedimentary environment is most likely to produce large-scale cross-bedding in well-sorted, fine-to-medium sand?
(A) Aeolian (desert)
(B) Deep marine abyssal plain
(C) Lacustrine (lake) center
(D) Glacial moraine

112. The utility of palaeocurrent analysis in resource exploration is that it helps to:
(A) Predict the location of source rocks for petroleum and natural gas.
(B) Map the trends of porous and permeable sand bodies (reservoirs).
(C) Determine the thermal maturity of organic matter within the basin.
(D) Identify the specific geological age of the sedimentary basin.

113. Arrange the following processes in the correct sequence for the formation of a clastic sedimentary rock.
I. Deposition
II. Weathering & Erosion
III. Lithification
IV. Transport
(A) II, IV, I, III
(B) I, II, III, IV
(C) IV, III, II, I
(D) II, I, IV, III

114. A rock made of consolidated volcanic ash is called a:
(A) Tuff
(B) Lava flow
(C) Granite
(D) Schist

115. Identify the correct statement about diagenesis.
(A) It occurs at the high temperatures and pressures characteristic of metamorphism.
(B) It includes all processes occurring on the surface before burial.
(C) It involves physical, chemical, and biological processes that alter sediment after deposition.
(D) It is synonymous with the process of sediment transport.

116. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : A sandstone composed almost entirely of quartz grains is considered mineralogically very mature.
Reason (R) : Extensive weathering and long transport distances selectively remove less stable minerals like feldspar and lithic fragments, concentrating the highly stable quartz.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

117. What distinguishes a breccia from a conglomerate?

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157. Which process is NOT a part of the overall process of sedimentation"?
(A) Erosion of source rock
(B) Transport of sediment
(C) Metamorphism of sedimentary rock
(D) Deposition of sediment

158. According to Dunham's classification, a limestone that is grain-supported and contains carbonate mud is a:
(A) Mudstone
(B) Wackestone
(C) Packstone
(D) Grainstone

159. A lacustrine environment refers to deposition in:
(A) A lake
(B) A river
(C) A desert
(D) A glacier

160. What is the primary information gained from the study of sedimentary structures?
(A) The absolute age of the rock in millions of years.
(B) The conditions of transport and deposition, such as current direction and flow regime.
(C) The precise mineral composition of the cement.
(D) The depth of the Mohorovičić discontinuity.

161. A 'recycled orogen' provenance is characterized by sediments rich in:
(A) Volcanic glass and euhedral crystals.
(B) Sedimentary and low-grade metamorphic rock fragments.
(C) Mature quartz grains and carbonate rock fragments.
(D) Gneiss, schist, and high-grade metamorphic minerals.

162. Given below are two statements:
Statement I : Granulometric analysis is essential for understanding the texture of clastic sedimentary rocks.
Statement II : The sorting of a sediment reflects the variation in energy of the depositing medium.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct, but Statement II is incorrect.
(D) Statement I is incorrect, but Statement II is correct.

163. The conversion of aragonite shells to calcite during diagenesis is an example of:
(A) Compaction
(B) Cementation
(C) Replacement (recrystallization)
(D) Dissolution

164. Symmetrical ripple marks are typically formed by:
(A) Unidirectional currents in a river.
(B) Wind blowing across a desert.
(C) A turbidity current in the deep sea.
(D) Oscillatory (back-and-forth) motion of waves.

165. Which of the following is an example of a continental depositional environment?
(A) Estuary
(B) Lagoon
(C) Alluvial fan
(D) Continental shelf

166. Match List I with List II.
List I: (Grain Type in Limestone)
P. Ooids
Q. Peloids
R. Intraclasts
S. Bioclasts
List II: (Description)
1. Fragments of shells or skeletons
2. Ripped-up and reworked pieces of semi-consolidated carbonate mud
3. Spherical, concentrically coated grains
4. Fecal pellets or micritized grains of unknown origin
(A) P-3, Q-4, R-2, S-1
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-2, R-4, S-1
(D) P-4, Q-3, R-1, S-2

167. A sandstone cemented by calcite will react with dilute hydrochloric acid. This cementation is a process of:
(A) Provenance

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(B) Sandstone
(C) Travertine
(D) Shale

212. What does a fining-upward" sequence of sediments generally signify?
(A) A progressive increase in depositional energy.
(B) A period of volcanic eruption.
(C) Deposition in a static, unchanging environment.
(D) A progressive decrease in depositional energy or a transgression.

213. Match List I with List II.
List I: (Palaeocurrent Indicator)
P. Asymmetrical Ripples
Q. Imbrication
R. Flute Casts
S. Cross-bedding
List II: (Type of Information)
1. Indicates direction of erosive turbidity current
2. Foresets dip in the direction of current flow
3. Steep side faces downstream
4. Clasts dip upstream
(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-4, R-1, S-2
(C) P-4, Q-3, R-2, S-1
(D) P-2, Q-1, R-4, S-3

214. The most unstable mineral at the Earth's surface, according to Goldich's stability series, is:
(A) Quartz
(B) Olivine
(C) Muscovite
(D) K-Feldspar

215. Consider the following statements:
1. Lithification converts loose sediment into solid rock.
2. Diagenesis includes lithification as well as other post-depositional changes.
3. Compaction increases the porosity of a sediment.
Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

216. A sedimentary rock formed from the accumulation of plant material is:
(A) Coal
(B) Limestone
(C) Sandstone
(D) Gypsum

217. A 'craton interior' provenance setting is typically characterized by sandstones that are:
(A) Compositionally immature, with abundant feldspar and volcanic fragments.
(B) Rich in metamorphic rock fragments and mica.
(C) Compositionally mature to supermature, dominated by well-rounded quartz grains.
(D) Poorly sorted and angular, typical of a greywacke.

218. The classification of limestones proposed by Dunham is based on:
(A) Depositional texture
(B) Mineral composition
(C) Fossil content
(D) Color

219. Which process involves the precipitation of new minerals in the pore spaces of a sediment, binding the grains together?
(A) Compaction
(B) Abrasion
(C) Erosion
(D) Cementation

220. Given below are two statements:
Statement I : Evaporites are clastic sediments transported by wind.
Statement II : Evaporites are chemical sediments formed by precipitation from a concentrated aqueous solution due to evaporation.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct, but Statement II is incorrect.
(D) Statement I is incorrect, but Statement II is correct.

221. An estuary is a:
(A) Continental environment.

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179. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : Mud cracks found in a sedimentary rock indicate periodic subaerial exposure.
Reason (R) : These structures form when fine-grained, water-saturated sediment dries, shrinks, and cracks.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

180. The separation of heavy minerals using liquids like bromoform is possible because these minerals:
(A) Are significantly more magnetic than associated light mineral grains.
(B) Are much larger in average size than the accompanying light minerals.
(C) Are more soluble in the heavy liquid medium used during separation.
(D) Have a higher specific gravity than the liquid, causing them to sink.

181. In the context of fluid dynamics, the flow in which fluid particles move in a chaotic, eddying motion is called:
(A) Laminar flow
(B) Plastic flow
(C) Turbulent flow
(D) Static flow

182. A rock that is composed of a mixture of sand, silt, and clay, with over 15% clay matrix, is best termed:
(A) Quartz arenite
(B) Greywacke
(C) Arkose
(D) Conglomerate

183. Given below are two statements:
Statement I : The ZTR Index (Zircon-Tourmaline-Rutile) is a measure of the tectonic provenance of a sediment.
Statement II : The ZTR Index is an indicator of the mineralogical maturity of a clastic sediment.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct, but Statement II is incorrect.
(D) Statement I is incorrect, but Statement II is correct.

184. A 'point bar' is a depositional feature commonly associated with which environment?
(A) A meandering fluvial system
(B) A deep marine basin
(C) An aeolian dune field
(D) A glacial moraine

185. What does the term provenance" in sedimentology specifically refer to?
(A) The diagenetic history of the rock.
(B) The depositional environment.
(C) The source area from which the sediment was derived.
(D) The age of the fossils within the rock.

186. The formation of rock salt (halite) occurs in which of the following environments?
(A) A restricted basin in an arid climate.
(B) A rapidly flowing mountain stream.
(C) A deep-sea trench.
(D) The base of a glacier.

187. Which of the following is a clastic sedimentary rock?
(A) Limestone
(B) Gypsum
(C) Chert
(D) Conglomerate

188. Imbrication of flat pebbles in a conglomerate is a useful palaeocurrent indicator because the pebbles typically dip:
(A) In the downstream direction.
(B) In the upstream direction.
(C) Perpendicular to the flow direction.
(D) Randomly, with no preferred orientation.

189. The textural maturity of a sandstone increases with:
(A) Increasing clay content and decreasing sorting.
(B) Decreasing grain roundness.
(C) Increasing degree of sorting and grain

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roundness.
(D) Proximity to the source area.

190. Match List I with List II.
List I: (Rock Type)
P. Sandstone
Q. Limestone
R. Rock Salt
S. Coal
List II: (General Classification)
1. Chemical
2. Organic
3. Clastic
4. Carbonate
(A) P-3, Q-4, R-1, S-2
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-1, R-4, S-2
(D) P-4, Q-3, R-2, S-1

191. The term 'arenaceous' refers to a sediment or sedimentary rock with a grain size corresponding to:
(A) Sand
(B) Clay
(C) Silt
(D) Gravel

192. Arrange the following steps of a provenance study in a logical order.
I. Interpretation of source rock type and location
II. Separation of heavy minerals
III. Petrographic analysis of grain composition
IV. Field sampling of sandstone
(A) IV, II, III, I
(B) I, II, III, IV
(C) IV, III, II, I
(D) II, IV, I, III

193. Which of the following statements about the origin of sediments is correct?
(A) Sediments originate only from the breakdown of igneous rocks.
(B) Sediments can be derived from igneous, metamorphic, and pre-existing sedimentary rocks.
(C) Sediments are formed exclusively by chemical precipitation from seawater.
(D) Sediments originate primarily from extraterrestrial materials.

194. The process by which pressure from overlying sediments reduces the pore space in a buried sediment layer is called:
(A) Compaction
(B) Cementation
(C) Dissolution
(D) Recrystallization

195. Consider the following statements about depositional environments:
1. Fluvial environments relate to rivers and streams.
2. Lacustrine environments relate to lakes.
3. Aeolian environments relate to wind action.
Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

196. In Dunham's classification, a 'boundstone' refers to a carbonate rock where:
(A) The components are not in contact and float in a mud matrix.
(B) The components are grain-supported but contain mud matrix.
(C) The components are grain-supported and lack mud.
(D) The original components were bound together during deposition.

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197. Which of the following is NOT a primary sedimentary structure?
(A) Bedding
(B) Ripple marks
(C) Cleavage
(D) Graded bedding

198. The significance of analyzing grain roundness in a clastic rock is that it generally indicates the:
(A) Mineral composition of the grain.
(B) Duration and intensity of transport abrasion.
(C) Absolute age of the grain.
(D) Tectonic setting of the source.

199. A lagoonal environment is typically characterized by:
(A) High-energy, coarse-grained deposits.
(B) Large-scale desert dunes.
(C) Poorly sorted glacial deposits.
(D) Low-energy, fine-grained sediments like

mud and silt.

200. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : Stylolites are irregular surfaces within carbonate rocks where minerals have been removed by pressure solution.
Reason (R) : They are primary sedimentary structures formed at the time of deposition.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

201. Which term describes the complete set of processes that cause physical and chemical changes in sediment after its deposition?
(A) Provenance
(B) Transport
(C) Diagenesis
(D) Erosion

202. Which of the following is a volcanoclastic sediment?
(A) Ash fall deposit (tuff)
(B) Oolitic limestone
(C) Rock salt
(D) River sand

203. Given below are two statements:
Statement I : Palaeocurrent analysis is of little significance in quality assessment for reservoirs.
Statement II : The direction of ancient currents determines the geometry and trend of sand bodies.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct, but Statement II is incorrect.
(D) Statement I is incorrect, but Statement II is correct.

204. The classification of sandstone depends on the triangular plot of which three components?
(A) Quartz, Clay, Carbonate
(B) Quartz, Feldspar, Rock Fragments
(C) Sand, Silt, Clay
(D) Zircon, Tourmaline, Rutile

205. The movement of sediment grains by bouncing and hopping along the bed is called:
(A) Suspension
(B) Traction
(C) Saltation
(D) Solution

206. A turbidite is a characteristic deposit of which environment?
(A) Aeolian
(B) Fluvial
(C) Lacustrine
(D) Deep marine

207. Which of the following is an example of a transitional" depositional environment?
(A) Beach
(B) Alluvial Fan
(C) Deep Sea
(D) Desert

208. The main purpose of granulometric analysis of a clastic sediment is to:
(A) Determine its chemical composition.
(B) Determine the distribution of its particle sizes.
(C) Determine its absolute age.
(D) Determine its provenance.

209. The term 'rudite' is used for sedimentary rocks where the dominant grain size is:
(A) Clay
(B) Gravel
(C) Silt
(D) Sand

210. In a sediment provenance study, what does a high percentage of feldspar typically suggest?
(A) Derivation from a granitic or gneissic source rock with rapid erosion and burial.
(B) A long and intense weathering history.
(C) A source area with a humid, tropical climate.
(D) A source area composed of pre-existing sedimentary rocks.

211. Which of the following is a chemical sedimentary rock?
(A) Conglomerate

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(C) Fluid viscosity has no impact on settling velocity.
(D) Particle shape is the only factor controlling settling velocity.

233. Which of these is an example of an organic" sedimentary structure?
(A) Flute cast
(B) Load cast
(C) Stromatolite
(D) Raindrop imprint

234. In the classification of sandstones, 'greywacke' is distinguished from 'arenite' by having:
(A) A higher percentage (>15%) of fine-grained matrix.
(B) A higher percentage of quartz.
(C) A lower percentage of feldspar.
(D) Rounded grains instead of angular grains.

235. The process of lithification involves which two main sub-processes?
(A) Erosion and Transport
(B) Weathering and Deposition
(C) Melting and Crystallization
(D) Compaction and Cementation

236. Consider the following statements about sedimentary textures:
1. Sorting refers to the uniformity of grain size in a sediment.
2. Roundness refers to the angularity of the corners of a grain.
3. Well-rounded grains always indicate a volcanic origin.

Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

237. Which depositional environment is characterized by well-sorted, fine-grained sand with large-scale cross-bedding, and an absence of fossils?
(A) Deep marine
(B) Fluvial
(C) Aeolian
(D) Lacustrine

238. Given below are two statements:

Statement I : Primary sedimentary structures form at the time of deposition.
Statement II : Secondary sedimentary structures form after deposition, during diagenesis.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct, but Statement II is incorrect.
(D) Statement I is incorrect, but Statement II is correct.

239. The term 'argillite' refers to a lithified rock primarily composed of:
(A) Clay and silt particles
(B) Sand grains
(C) Gravel
(D) Carbonate mud

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240. The continental shelf is part of which major category of depositional environment?
(A) Continental
(B) Shallow Marine
(C) Transitional
(D) Deep Marine

241. A 'biosparite' in Folk's limestone classification is a rock that is:
(A) Mud-supported, with skeletal fragments floating in a micrite matrix.
(B) Grain-supported, composed of skeletal fragments, and cemented by sparry calcite.
(C) Composed primarily of ooids cemented by sparry calcite.
(D) Composed primarily of fecal pellets in a micrite matrix.

242. In a provenance study, an abundance of kyanite, sillimanite, and staurolite in the heavy mineral suite would strongly suggest a source area composed of:
(A) Medium- to high-grade metamorphic rocks.
(B) Unaltered granitic rocks.
(C) Basaltic volcanic rocks.
(D) Pre-existing limestones.

243. The formation of concretions within a sandstone or shale is a process that occurs:
(A) During sediment transport.

(B) Marine environment.
(C) Transitional environment.
(D) Glacial environment.

222. The study of the textures of sedimentary rocks is genetically significant because texture provides insights into the:
(A) Absolute age of the rock.
(B) Magnetic field at the time of deposition.
(C) Metamorphic grade of the rock.
(D) Transport and depositional history of the sediment.

223. The term 'dolomite' can refer to both a mineral ($CaMg(CO_3)_2$) and a rock. The rock is more formally called:
(A) Dolostone
(B) Limestone
(C) Marble
(D) Anhydrite

224. Which of the following is a primary sedimentary structure indicative of the 'up' direction in a stratigraphic sequence?
(A) Stylolite
(B) Graded bedding
(C) Concretion
(D) Joint

225. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : In a stable cratonic setting, sandstones are often mineralogically mature.
Reason (R) : Stable tectonic settings allow for prolonged weathering and transport, which selectively eliminates unstable minerals.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

226. All of the following are physical processes contributing to the formation of sediments EXCEPT:
(A) Hydrolysis
(B) Frost action
(C) Abrasion during transport
(D) Thermal expansion and contraction

227. The term used to describe a rock made of lithified clay is:
(A) Sandstone
(B) Conglomerate
(C) Claystone or Shale
(D) Limestone

228. Arrange the following depositional environments from most landward (continental) to most seaward (marine).
I. Alluvial fan
II. Delta
III. Abyssal plain
IV. Continental shelf
(A) I, II, IV, III
(B) I, IV, II, III
(C) II, I, IV, III
(D) III, IV, II, I

229. A rock composed of angular fragments of volcanic bombs, blocks, and lapilli is best described as:
(A) A conglomerate
(B) A shale
(C) A pyroclastic breccia
(D) A bioclastic limestone

230. The two main types of sedimentary rocks based on origin are:
(A) Felsic and Mafic
(B) Clastic and Chemical/Biochemical
(C) Intrusive and Extrusive
(D) Foliated and Non-foliated

231. The primary utility of heavy mineral analysis in provenance studies is that:
(A) Heavy minerals are always easy to identify.
(B) All sediments contain the same suite of heavy minerals.
(C) Heavy minerals directly indicate the age of deposition.
(D) Heavy mineral assemblages can be fingerprinted to specific source rock terranes.

232. What is the fundamental principle behind Stoke's Law of settling?
(A) Larger, denser particles settle faster in a fluid than smaller, less dense particles.
(B) All particles settle at the same velocity regardless of size.

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(B) Transport
(C) Erosion
(D) Diagenesis

168. The study of the relationship between sedimentary facies and their depositional environments is a central theme of:
(A) Sedimentology
(B) Geochronology
(C) Igneous Petrology
(D) Structural Geology

169. What is the significance of mineral stability in provenance analysis?
(A) All minerals are equally stable across environments, so it has no significance.
(B) The presence of unstable minerals indicates that the source rock was purely igneous.
(C) Unstable minerals indicate short transport distances and/or arid climates.
(D) The presence of stable minerals indicates that the source rock was metamorphic.

170. Arrange the following diagenetic environments in order of increasing depth/temperature.
I. Eogenesis (shallow burial)
II. Telogenesis (uplift and weathering)
III. Mesogenesis (deep burial)
(A) I, III, II
(B) II, I, III
(C) I, II, III
(D) III, I, II

171. A 'magmatic arc' provenance setting would be expected to yield sandstones rich in:
(A) Quartz and carbonate fragments.
(B) K-feldspar and high-grade metamorphic rock fragments.
(C) Chert and sedimentary rock fragments.
(D) Volcanic lithic fragments, plagioclase, and pyroxene.

172. A key objective of granulometric analysis is to quantify the textural parameters of a clastic sediment. Which parameter measures the degree of uniformity of grain size?
(A) Mean
(B) Sorting
(C) Skewness
(D) Kurtosis

173. Which of the following pairs is incorrectly matched?
(A) Rudite - Conglomerate
(B) Arenite - Sandstone
(C) Evaporite - Greywacke
(D) Argillite - Shale

174. Consider the following statements about lithification:
1. It only involves the physical compaction of sediments.
2. Cementation, the precipitation of minerals in pore spaces, is a key part of lithification.
3. It transforms unconsolidated sediments into coherent sedimentary rock.

Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

175. The term 'clastic' in sedimentology refers to rocks composed of:
(A) Fragments of pre-existing rocks.
(B) Chemically precipitated minerals.
(C) The accumulated remains of organisms.
(D) Volcanic lava flows.

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176. Which of the following is an example of a secondary sedimentary structure formed by chemical processes during diagenesis?
(A) Lamination
(B) Geode
(C) Cross-bedding
(D) Graded bedding

177. The classification of dolomite and dolostone is often based on crystal size and texture. Which term describes a dolomite with large, clearly visible crystals?
(A) Aphanocrystalline
(B) Phanerocrystalline
(C) Microcrystalline
(D) Micritic

178. The primary difference between continental, transitional, and marine environments is their:
(A) Geographic location relative to the shoreline.
(B) Dominant mineral composition.
(C) Age of deposition.
(D) Degree of tectonic activity.

(B) At the moment of deposition.
(C) During diagenesis.
(D) During surface weathering.

244. Match List I with List II.
List I: (Process)
P. Saltation
Q. Suspension
R. Traction
S. Lithification
List II: (Result/Description)
1. Transport of finest particles within the fluid
2. Conversion of loose sediment to rock
3. Bouncing/skipping of grains along the bed
4. Rolling/sliding of coarsest particles on the bed
(A) P-1, Q-3, R-4, S-2
(B) P-3, Q-1, R-2, S-4
(C) P-3, Q-1, R-4, S-2
(D) P-4, Q-2, R-1, S-3

245. Varves, which are rhythmically laminated couplets of fine and coarse sediment, are characteristic deposits of which environment?
(A) Aeolian desert
(B) High-energy beach
(C) Glacial lake (lacustrine)
(D) Deep-sea abyssal plain

246. Which of the following is NOT a major type of depositional environment?
(A) Continental
(B) Metamorphic
(C) Transitional
(D) Marine

247. The term for a limestone composed predominantly of fossil fragments is:
(A) Oolitic limestone
(B) Travertine
(C) Micrite
(D) Coquina or Bioclastic limestone

248. The primary factor that distinguishes a conglomerate from a breccia is:
(A) The roundness of the clasts.
(B) The size of the clasts.
(C) The composition of the clasts.
(D) The sorting of the clasts.

249. What is the significance of the Goldich stability series for provenance analysis?
(A) It ranks minerals by their hardness.
(B) It ranks minerals by their melting point.
(C) It ranks minerals by their resistance to chemical weathering at the Earth's surface.
(D) It ranks minerals by their magnetic susceptibility.

250. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : Dunham's classification of carbonate rocks is based on depositional texture.
Reason (R) : It focuses on whether the grains are mud-supported or grain-supported and the amount of mud matrix present.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

251. A sandstone containing more than 25% feldspar grains is called:
(A) Quartz arenite
(B) Litharenite
(C) Greywacke
(D) Arkose

252. The classification of clastic sedimentary rocks (rudite, arenite, argillite) is primarily based on:
(A) Mineral composition
(B) Particle size
(C) Color
(D) The presence of fossils

253. Which of the following is a key element of a depositional environment?
(A) The metamorphic grade of the basement.
(B) The age of the solar system.
(C) The physical, chemical, and biological processes operating in the area of deposition.
(D) The composition of the Earth's core.

254. A bed showing a progressive increase in grain size from bottom to top is known as:
(A) Normally graded bedding
(B) Cross-bedding
(C) Laminated bedding

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(D) Inversely or reverse graded bedding

255. Given below are two statements:
Statement I : Heavy minerals are those with a specific gravity less than 2.0.
Statement II : The separation of heavy minerals is not useful for provenance analysis.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct, but Statement II is incorrect.
(D) Statement I is incorrect, but Statement II is correct.

256. Which of the following is an example of a volcanoclastic sediment?
(A) A river gravel
(B) A volcanic ash layer
(C) A beach sand
(D) A deposit of rock salt

257. The term for the source area of a sediment is:
(A) Diagenesis
(B) Provenance
(C) Facies
(D) Lithification

258. Which of the following is a primary sedimentary structure formed by the action of currents or waves?
(A) Ripple Mark
(B) Concretion
(C) Stylolite
(D) Joint

259. What is the main difference between chemical and clastic sedimentary rocks?
(A) Clastic rocks contain fossils, while chemical rocks do not.
(B) Clastic rocks are always coarse-grained, while chemical rocks are always fine-grained.
(C) Clastic rocks are made of fragments, while chemical rocks are made of precipitated minerals.
(D) Clastic rocks form on land, while chemical rocks form in the ocean.

260. Consider the following statements regarding sedimentary rock textures:
1. Well-sorted sediments imply a constant energy level during deposition.
2. Angular grains suggest a short transport distance from the source.
3. Textural maturity increases with transport distance.

Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

261. In the context of sedimentation, 'fluid flow' refers to the movement of:
(A) Magma within the Earth.
(B) Oil and gas through a reservoir rock.
(C) Water, air, or ice that transports sediment.
(D) Tectonic plates.

262. Which of the following is a defining characteristic of a 'rudite'?
(A) It is composed of sand-sized particles.
(B) It is composed of gravel-sized (>2mm) particles.
(C) It is composed of clay-sized particles.
(D) It is composed of chemically precipitated minerals.

263. A sequence of rocks showing a transition from deep-water shales to shallow-water sandstones to coastal plain coals would represent a:
(A) Transgression (sea-level rise)
(B) Period of tectonic stability
(C) Rapid subsidence event
(D) Regression (sea-level fall)

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264. Arrange the following processes chronologically from the start to the end of a sedimentary rock's formation.
I. Cementation
II. Transport
III. Weathering
IV. Deposition
(A) III, II, IV, I
(B) II, III, I, IV
(C) I, IV, II, III
(D) III, IV, II, I

265. The utility of heavy minerals in provenance analysis stems from the fact that:
(A) They are the most abundant component of most sandstones.
(B) They are chemically very reactive and change composition easily.
(C) Specific mineral suites can be linked to specific source rock types.
(D) They are always the same regardless of the source rock.

266. Which type of sedimentary structure provides the most reliable indication of way-up" or the original top of a sedimentary bed?
(A) Graded bedding
(B) Parallel lamination
(C) Symmetrical ripple marks
(D) Stylolites

267. A limestone made up of ooids, cemented by sparry calcite, would be classified by Folk as:
(A) Oomicrite
(B) Biomicrite
(C) Pelsparite
(D) Oosparite

268. The primary mechanism of transport for clay and fine silt in a river is:
(A) Traction
(B) Suspension
(C) Saltation
(D) Solution

269. What is the significance of palaeocurrents in assessing sediment dispersal patterns?
(A) They help determine the age of the sediment.
(B) They indicate the level of diagenesis.
(C) They show the direction from which sediment was transported into a basin.
(D) They measure the porosity of the final rock.

270. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : Greywackes are considered texturally and compositionally immature sandstones.
Reason (R) : They contain a high proportion of unstable minerals and rock fragments as well as a significant clay matrix.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

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271. Match List I with List II.
List I: (Sedimentary Environment)
P. Beach
Q. Deep Marine (Abyssal)
R. Alluvial Fan
S. Lagoon
List II: (Dominant Sediment Type/Feature)
1. Fine-grained mud and pelagic ooze
2. Well-sorted sand
3. Poorly sorted breccias and conglomerates
4. Laminated muds, possibly with evaporites
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-1, R-4, S-3
(C) P-2, Q-1, R-3, S-4
(D) P-3, Q-4, R-1, S-2

272. The lithification" specifically refers to the processes that:
(A) Break down rock at the Earth's surface.
(B) Convert unconsolidated sediment into solid rock.
(C) Transport sediment from its source.
(D) Create primary sedimentary structures.

273. Given below are two statements:
Statement I : The grain size of a clastic sediment is a reflection of the energy of the transport and depositional medium.
Statement II : High-energy environments, like swift rivers, can transport large particles, while low-energy environments can only keep fine particles in suspension.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct, but Statement II is incorrect.
(D) Statement I is incorrect, but Statement II is correct.

274. In a 'recycled orogen' provenance type, what kind of lithic fragments would be most abundant in the resulting sandstone?
(A) Chert, siltstone, and low-grade metamorphic

about the transport mechanisms, energy levels, and sorting processes that occurred in the ancient environment.

27. (D) Concretions
Primary structures like ripple marks or graded bedding form during the depositional process. Secondary structures develop later during diagenesis after the sediment has been buried. Concretions are secondary features formed by the localized precipitation of mineral cement around a nucleus, such as a fossil or organic matter. They often grow outward, creating hard, rounded masses within the surrounding sedimentary layers.

28. (B) A rock composed of clay and silt-sized particles.
Argillite is a term used in the classification of fine-grained clastic sedimentary rocks. It refers to a lithified rock predominantly composed of particles in the clay and silt size ranges. Unlike shale, which is characterized by its fissility or tendency to split into thin layers, argillite is generally more massive or blocky. It represents the lithified equivalent of unconsolidated mud.

29. (B) P-4, Q-3, R-1, S-2
Different environments produce characteristic sedimentary deposits. Aeolian systems create well-sorted, cross-bedded sandstones through wind action. Glacial environments are marked by till, an unsorted mixture of various grain sizes. Deep marine settings often feature turbidites deposited by gravity flows. Fluvial environments typically consist of a mix of channel-filling sands and fine-grained muds deposited on floodplains during high-water events.

30. (D) Volcanoclastic
Volcanoclastic sediments are composed of fragments derived from volcanic activity. This includes various materials such as volcanic glass shards, individual crystals, and pieces of volcanic rock that were ejected during explosive eruptions or redistributed by surface processes. These sediments are distinct from purely siliciclastic or chemical deposits and provide critical information about ancient volcanic provinces and regional tectonic activity.

31. (D) 1, 2 and 3
Heavy minerals are defined by having a specific gravity greater than quartz, which is the most common constituent of sand. Because of their density, they are typically separated from lighter minerals using heavy liquids. The ZTR index, based on the abundance of Zircon, Tourmaline, and Rutile, is a standard metric used to assess the mineralogical maturity of a sediment sample.

32. (B) Lithification
Sediment transport involves the physical movement of particles by a fluid medium through processes like saltation, suspension, and traction. Lithification is not a transport mechanism; rather, it is the post-depositional process that converts loose sediment into solid rock. Lithification occurs only after transport has ceased and the particles have accumulated in a depositional basin, undergoing compaction and cementation.

33. (B) The dominant clasts are larger than 2 mm in diameter.
A rudite is defined by the size of its constituent clasts. In the standard classification of clastic rocks, rudites are those where the dominant particles are larger than two millimeters in diameter. This category includes gravel-sized materials such as pebbles, cobbles, and boulders. The term encompasses common rock types like conglomerate and breccia, which reflect high-energy transport in ancient environments.

34. (A) Ooids
Ooids are small, spherical to subspherical grains composed of concentric layers of calcium carbonate precipitated around a central nucleus, such as a shell fragment or sand grain. They typically form in warm, shallow, high-energy marine environments where they are constantly agitated by wave action. When lithified, they form oolitic limestones, which are important indicators of specific paleoenvironmental conditions during deposition.

35. (C) Statement I is correct, but Statement II is incorrect.
Provenance analysis is the study of the origin of sedimentary material. It involves identifying the parent rock types, their geographic location, and the tectonic setting of the source area.

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(A) It is located entirely on land, far from the sea.
(B) It is located in the deep ocean, below the photic zone.
(C) It is characterized exclusively by volcanic activity.
(D) It lies at the boundary between continental and marine environments.

287. Which of the following is a clastic sedimentary rock composed of sand-sized grains?
(A) Sandstone
(B) Shale
(C) Conglomerate
(D) Limestone

288. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : Sedimentary structures are useful in interpreting depositional environments.
Reason (R) : Different structures form under specific conditions; for example, mud cracks indicate subaerial exposure.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

289. The term for sediment grains with a size between 1/16 mm and 2 mm is:
(A) Silt
(B) Sand
(C) Gravel
(D) Clay

290. Arrange the following grain types by their typical size, from largest to smallest.
I. Sand
II. Pebble
III. Clay
IV. Silt
(A) II, I, IV, III
(B) I, II, IV, III
(C) II, IV, I, III
(D) IV, III, I, II

291. The primary components of an 'arenite' are:
(A) Gravel-sized clasts
(B) Silt and clay particles
(C) Sand-sized grains
(D) Carbonate minerals

292. A volcano-clastic" sediment is composed of:
(A) Fragments derived from the weathering of continental rocks.
(B) Shells and organic remains.
(C) Precipitated salts from an evaporating sea.
(D) Fragmental material ejected from a volcano.

293. Given below are two statements:
Statement I : The texture of a sedimentary rock includes features like grain size, sorting, and roundness.
Statement II : The structure of a sedimentary rock includes large-scale features like bedding and cross-bedding.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct, but Statement II is incorrect.
(D) Statement I is incorrect, but Statement II is correct.

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294. The mineral stability series indicates that which of the following minerals is most likely to survive long transport?
(A) Olivine
(B) Quartz
(C) Pyroxene
(D) Plagioclase Feldspar

295. In Dunham's classification, a limestone that is matrix-supported (mud-supported) is either a:
(A) Packstone or Grainstone
(B) Boundstone or Crystalline Carbonate
(C) Arenite or Rudite
(D) Mudstone or Wackestone

296. A fluvial system refers to a depositional environment dominated by:
(A) Rivers and streams
(B) Wind
(C) Glaciers
(D) Lakes

297. Match List I with List II.

are often characterized by their higher porosity and cleaner appearance.

45. (C) A re-orientation of grains leading to a decrease in porosity.
Mechanical compaction is a primary process during the burial of sediment. As the weight of overlying material increases, the grains are pushed closer together. This leads to a re-orientation of the sedimentary particles and a significant reduction in the primary porosity and bulk volume of the sediment. Compaction is the first major step in transforming loose sand into lithified sandstone.

46. (D) Olivine
Cementation is the process where minerals precipitate in the pore spaces of a sediment. The most common cements in sandstones are calcite, silica (usually as quartz overgrowths), and iron oxides like hematite. Olivine is not a cement; it is a high-temperature silicate mineral that is chemically unstable at the Earth's surface and would not precipitate from low-temperature groundwater.

47. (A) The transition from laminar to turbulent flow.
The Reynolds number is a dimensionless value used in fluid mechanics to characterize flow patterns. In the context of sedimentation, it is used to predict whether fluid flow will be laminar or turbulent. Laminar flow occurs at low Reynolds numbers, while turbulent flow, which is more effective at eroding and transporting sediment, occurs once a critical Reynolds number is exceeded.

48. (B) Breccia
A breccia is a clastic sedimentary rock composed of angular, gravel-sized fragments. The sharp edges of the clasts indicate that they have not undergone significant transport or abrasion. Breccias are typically poorly sorted and can form in various settings, such as at the base of cliffs, along fault zones, or as a result of explosive volcanic activity near the source.

49. (B) Different heavy mineral suites can be characteristic of specific source rock types.
Heavy minerals are valuable in provenance analysis because specific mineral assemblages are characteristic of particular source rocks. For example, minerals like kyanite or staurolite indicate metamorphic sources, while chromite may suggest mafic or ultramafic origins. By identifying these suites, geologists can determine the lithology and tectonic history of the region where the sediment was originally eroded and weathered.

50. (A) The size of the dolomite crystals.
The classification of dolomite rocks, or dolostones, often focuses on the texture and size of the dolomite crystals. Because many dolostones form through the replacement of limestone, the size of the resulting crystals (phanerocrystalline vs. aphanocrystalline) is a key descriptive feature. This helps geologists understand the timing and conditions of the dolomitization process during the rock's diagenetic history.

51. (A) 1 and 2 only
Sphericity and roundness are two distinct textural parameters used to describe sedimentary grains. Sphericity measures how closely a grain's overall shape resembles a sphere, which is largely inherited from the source. Roundness describes the smoothness of the grain's edges and corners, which increases with transport. A grain can have high sphericity but remain angular if it hasn't been abraded.

52. (D) Provenance
Provenance is the sedimentological term that describes the origin of a sediment. It encompasses the geographic location of the source area and the specific parent rock types that were eroded to produce the particles. Analysis of provenance is essential for reconstructing ancient paleogeography and understanding the tectonic evolution of a region, as well as the history of sediment dispersal.

53. (A) P-3, Q-2, R-1, S-4
Flute casts are erosional features formed by turbulent scour on the seabed. Mud cracks result from the desiccation of exposed fine-grained sediment. Stromatolites are organic structures produced by microbial activity, typically in tidal flats. Hummocky cross-stratification is a distinctive sedimentary structure formed on the continental shelf by the action of large storm waves, indicating high-energy event deposition.

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ANSWERS

1. (B) The deposition of sediments by agents like water, wind, or ice.
Sedimentation is the fundamental process involving the accumulation or settling of particles. In a geological context, it specifically refers to the deposition of mineral or organic matter by agents of transport like water, wind, or ice. This process occurs once the energy of the transporting medium decreases sufficiently to allow particles to settle under the influence of gravity.

2. (A) Saltation
Saltation is a specific mode of sediment transport where particles, typically sand-sized, move along a bed in a series of short hops or bounces. This occurs when the fluid flow provides enough lift to temporarily suspend the grains, but they eventually fall back to the bed due to gravity, often dislodging other particles upon impact with the surface.

3. (A) Both Statement I and Statement II are correct.
Fluid dynamics in sedimentation distinguishes between two primary flow regimes. Laminar flow occurs at low velocities where fluid layers move parallel to each other without mixing. In contrast, turbulent flow involves chaotic, eddy-driven motion at higher velocities. Turbulent flow is more effective at suspending and transporting sediment particles due to the irregular vertical components of its flow velocity.

4. (D) Stylolites
Primary sedimentary structures form during or shortly after deposition, such as bedding or ripple marks. Secondary structures develop after lithification due to chemical or physical processes. Stylolites are secondary features produced by pressure solution during deep burial, appearing as jagged, irregular surfaces where mineral matter has been dissolved and removed from the rock body by intense lithostatic pressure.

5. (C) To reconstruct the direction of ancient currents and sediment transport.
Palaeocurrent analysis involves studying sedimentary structures that preserve information about ancient flow directions. By measuring the orientation of features like cross-bedding, flute casts, or ripple marks, geologists can reconstruct the direction of current flow and sediment transport within ancient basins. This data is vital for understanding basin geometry and predicting the trends of porous and permeable sand bodies.

6. (B) Rudites consist of gravel-sized clasts, including boulders, cobbles, and pebbles.
The classification of terrigenous sediments is primarily based on grain size. Rudites are coarse-grained rocks composed of clasts larger than two millimeters in diameter. This category includes common sedimentary rocks such as conglomerates, which contain rounded clasts, and breccias, which are characterized by angular clasts. These deposits typically reflect high-energy environments capable of transporting and depositing heavy rock fragments.

7. (A) P-4, Q-2, R-1, S-3
Sedimentary rocks are categorized by the size of their constituent particles using standard scales. Rudites represent the coarsest fraction with grains exceeding two millimeters. Arenites, or sandstones, fall between two millimeters and one-sixteenth of a millimeter. Siltstones range from one-sixteenth down to one-two hundred fifty-sixth of a millimeter, while argillites consist of the finest clay-sized particles smaller than that.

8. (A) Greywacke
Sandstones are classified based on the proportions of framework grains and matrix. An arenite contains very little matrix, typically less than fifteen percent. When a rock contains more than fifteen percent silt and clay-sized matrix material mixed with sand grains, it is termed a wacke. Greywacke is a common type of wacke often containing unstable minerals and lithic fragments.

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List I: (Term)
P. Granulometry
Q. Palaeocurrent Analysis
R. Provenance Analysis
S. Diagenesis Study
List II: (Field of Study)
1. Reconstructing source rocks
2. Post-depositional changes
3. Analysis of grain size distribution
4. Determining ancient flow directions
(A) P-3, Q-4, R-1, S-2
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-1, R-4, S-2
(D) P-4, Q-3, R-2, S-1

298. What is the process that causes sediments to become more rounded and smaller with increased transport distance?
(A) Abrasion
(B) Cementation
(C) Compaction
(D) Lithification

299. Which of these features is a secondary sedimentary structure?
(A) Bedding plane
(B) Cross-stratification
(C) Ripple mark
(D) Concretion

300. The ultimate origin of the material that forms clastic sedimentary rocks is:
(A) Chemical precipitation
(B) The weathering of pre-existing rocks
(C) Mantle plumes
(D) Organic activity

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spaces, effectively gluing the particles together into a coherent, solid rock mass.

18. (A) The original source area and rock types from which the sediment was derived.
Provenance in sedimentology refers to the origin of sedimentary particles. It encompasses the geographic location of the source area and the specific types of parent rocks that were weathered and eroded to produce the sediment. Understanding provenance is crucial for reconstructing ancient paleogeography, tectonic settings, and the drainage patterns that delivered material to a particular sedimentary basin over time.

19. (C) Zircon
Mineral stability at the Earth's surface determines which minerals survive transport. Zircon is exceptionally stable due to its chemical inertness and physical hardness. Unlike minerals like olivine or calcite, which weather rapidly, zircon can endure multiple cycles of erosion and redeposition. This persistence makes it a highly reliable indicator in provenance studies for tracing long-term geological history and source area.

20. (D) Dunham's classification
Dunham's classification is a widely used system for carbonate rocks based on their depositional texture. It categorizes limestones by observing the relationship between the framework grains and the mud matrix. Key criteria include whether the rock is mud-supported, such as wackestones, or grain-supported, such as packstones and grainstones. This focus provides immediate insights into the energy levels of environments.

21. (C) Statement I is correct, but Statement II is incorrect.
Diagenesis includes all chemical, physical, and biological changes that affect a sediment after its initial deposition but before the onset of metamorphism. These processes occur within the sedimentary basin during burial. In contrast, weathering is a surface process involving the breakdown of rocks into sediment. While both involve mineral alteration, weathering is the precursor to sedimentation rather than diagenesis.

22. (B) Traction
Traction is a mode of bedload transport where the coarsest sediment particles, such as pebbles and cobbles, move along the channel floor. These particles are too heavy to be lifted into suspension or to hop via saltation. Instead, they are moved by the force of the current through continuous rolling, sliding, or dragging along the sediment-water interface during flow.

23. (D) Deltaic
Depositional environments are classified by their geographic setting. Continental environments occur on land and include fluvial, lacustrine, and glacial systems. Marine environments are situated in the ocean. Deltaic environments are considered transitional because they form at the interface where a river enters a standing body of water, typically the sea, combining characteristics of both terrestrial and marine sedimentary systems.

24. (A) Organic (Biochemical)
Sedimentary rocks are categorized by their origin. Clastic rocks form from rock fragments, while chemical rocks form from inorganic precipitates. When a rock is composed primarily of the remains of organisms, such as shell fragments or skeletal debris, it is classified as an organic or biochemical sedimentary rock. Coquina is a well-known example of this type of limestone rock.

25. (A) Both A and R are true and R is the correct explanation of A.
Cross-bedding consists of inclined layers within a thicker bed, formed by the migration of ripples or dunes. The individual inclined layers, known as foresets, are deposited on the lee side of the bedform. Because these foresets dip in the direction of the current, cross-bedding serves as a reliable indicator for geologists attempting to reconstruct the ancient flow direction.

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26. (A) To measure the distribution of grain sizes within the sample.
Granulometric analysis is a fundamental technique in clastic sedimentology used to quantify the physical properties of a sediment sample. The primary goal is to measure the distribution of various grain sizes. By analyzing these distributions, geologists can calculate statistical parameters that provide information

9. (C) Angular grains suggest a long distance of transport from the source.
Texture encompasses grain size, shape, and arrangement. Angularity or roundness provides clues about the history of sediment transport. Grains become increasingly rounded as they collide and undergo abrasion during transport. Therefore, highly angular grains suggest that the sediment has traveled a very short distance from its source area or has experienced minimal mechanical wear before its final deposition.

10. (A) Both A and R are true and R is the correct explanation of A.
Stoke's Law defines the settling behavior of fine, spherical particles in a viscous fluid. It establishes that terminal settling velocity depends on particle size and the density contrast between the particle and the fluid. Larger, denser particles settle faster. This law is fundamental for understanding how fine-grained sediments, such as silt and clay, are deposited in quiet water environments.

11. (D) Separating and identifying the suite of heavy minerals.
Provenance analysis aims to identify the source area of sediments. Separating and identifying heavy minerals—those with high specific gravity—is a powerful tool for this purpose. Since different source rocks produce unique suites of heavy minerals like zircon, tourmaline, or rutile, analyzing these minerals allows geologists to fingerprint the parent rock types and reconstruct the tectonic history of source.

12. (A) 1 and 2 only
Depositional environments are categorized into continental, transitional, and marine settings. Continental environments include terrestrial systems like rivers and lakes. Transitional environments, such as deltas and lagoons, occur at the land-sea interface. Deep marine environments are typically low-energy settings where fine sediments settle, whereas high-energy conditions and coarse deposits are more characteristic of shallow marine or nearshore coastal areas.

13. (C) Lithification
Lithification is the collective term for processes that transform loose, unconsolidated sediment into solid sedimentary rock. This transformation typically occurs after burial and involves mechanical compaction, which reduces pore space, and chemical cementation, where minerals precipitate from groundwater to bind grains together. These post-depositional changes are essential stages in the rock cycle, following weathering, transport, and initial sediment deposition.

14. (D) Mud Cracks - Continuous submergence under water.
Sedimentary structures provide evidence of the conditions during deposition. Mud cracks are primary structures that form when fine-grained, water-saturated sediment is exposed to the air. As the sediment dries, it shrinks and cracks into polygonal patterns. Consequently, the presence of mud cracks in the geological record indicates periods of subaerial exposure and desiccation rather than continuous underwater submergence during formation.

15. (A) The velocity decreases.
According to Stoke's Law, the settling velocity of a particle is inversely proportional to the dynamic viscosity of the fluid. If the fluid becomes more viscous, it exerts greater resistance against the falling particle. Assuming all other variables like particle radius and density remain constant, an increase in fluid viscosity will result in a decrease in the terminal settling velocity.

16. (B) Stromatolite
Organic or biogenic sedimentary structures are formed by the activity of living organisms. Stromatolites are classic examples, consisting of layered or mounded structures created by the trapping and binding of sediment by microbial mats, primarily cyanobacteria. Unlike inorganic features like flute casts or load casts, stromatolites represent a direct interaction between biological processes and the physical accumulation of carbonate sediment.

17. (A) II, IV, I, III
The transition from sediment to rock follows a logical sequence. It begins with the deposition of sediment in a basin, followed by burial under subsequent layers. Increasing overburden pressure leads to compaction, which expels fluids and reduces porosity. Finally, cementation occurs as minerals precipitate in the remaining pore

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While the source rock strongly influences the initial mineralogy, the final composition is also affected by weathering and transport. However, it remains fundamentally linked to the parent rock properties.

36. (D) Cementation
Diagenesis refers to the physical and chemical changes that transform sediment into sedimentary rock after deposition. Cementation is a key diagenetic process where minerals precipitate from pore fluids and act as a glue between grains. In contrast, erosion, transportation, and weathering are surface processes that occur before or during the movement of sediment and are not part of diagenesis.

37. (C) Evaporite
Evaporites are a class of chemical sedimentary rocks that form through the evaporation of mineral-rich water, typically in restricted marine basins or saline lakes. As water evaporates, the concentration of dissolved ions increases until minerals like halite, gypsum, or anhydrite begin to precipitate. These rocks are important indicators of arid climates and restricted hydrological conditions in ancient geological settings.

38. (B) To understand the diagenetic history of the sediment.
The primary significance of analyzing palaeocurrent indicators is to reconstruct the flow direction of ancient currents. By measuring structures like cross-bedding or flute casts, geologists can determine the direction of sediment transport. This information is essential for understanding the paleogeography of a basin, mapping the distribution of different facies, and predicting the orientation of potentially resource-bearing sedimentary bodies.

39. (D) Glacial outwash plain - High energy
Different depositional environments are characterized by specific energy levels that control sediment size. Deep marine abyssal plains and the centers of lakes are typically low-energy environments. Aeolian dune fields involve moderate energy. Glacial outwash plains, however, are high-energy environments where rapidly flowing meltwater carries and deposits coarse-grained materials, often leading to poorly sorted but high-energy sedimentary sequences.

40. (A) I, IV, II, III
The Wentworth scale is a logarithmic scale used to classify sediment by grain size. In decreasing order of size, the sequence begins with boulders and cobbles, followed by pebbles, granules, and sand. The finest fractions are silt and clay. Therefore, a list containing cobble, pebble, sand, and silt is arranged correctly from the largest diameter to the smallest diameter particles.

41. (C) Normally graded
Graded bedding is a sedimentary structure where the grain size changes systematically within a single layer. Normal grading is characterized by a progressive decrease in grain size from the bottom of the bed to the top. This typically occurs as a high-energy current, such as a turbidity flow, loses velocity, allowing coarser particles to settle out first followed by finer material.

42. (A) Both A and R are true and R is the correct explanation of A.
The Goldich stability series describes the relative resistance of minerals to chemical weathering at the Earth's surface. It is generally the inverse of Bowen's reaction series. Minerals like olivine, which form at high temperatures and pressures, are the least stable at surface conditions. Conversely, minerals like quartz, which crystallize at lower temperatures, are chemically more resistant and persist longer.

43. (D) Estuary
Transitional depositional environments occur at the interface between land and sea. An estuary is a classic example, where a river meets the ocean and freshwater mixes with saltwater. Unlike continental environments like alluvial fans or deserts, or marine environments like deep-sea fans, estuaries are influenced by both fluvial processes and marine tides, creating unique sedimentological and biological characteristics.

44. (B) A sandstone with less than 15% silt-clay matrix.
In the classification of sandstones, the term 'arenite' specifically refers to a rock where sand-sized grains are the dominant component and the fine-grained matrix (silt and clay) constitutes less than fifteen percent of the rock's volume. This distinguishes arenites from wackes, which contain a higher proportion of matrix. Arenites

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fragments.
(B) Volcanic glass and basalt fragments.
(C) Gneiss and granite fragments.
(D) Ooids and bioclastic fragments.

275. A deposit of halite (rock salt) is classified as which type of sedimentary rock?
(A) Clastic
(B) Organic
(C) Evaporite (Chemical)
(D) Volcanoclastic

276. The term 'fabric' in a sedimentary rock refers to:
(A) The mineral composition of the grains.
(B) The overall color of the rock.
(C) The types of fossils present.
(D) The orientation and packing of the constituent grains.

277. The classification of sandstones into quartz arenite, arkose, and litharenite is primarily based on:
(A) Grain size
(B) The type of cement
(C) The relative abundance of quartz, feldspar, and rock fragments
(D) The degree of sorting

278. Which of the following is NOT a type of sedimentary provenance?
(A) Magmatic arc
(B) Asthenospheric mantle
(C) Continental block (Craton interior)
(D) Recycled orogen

279. The formation of dolomite in most geological settings is thought to occur through:
(A) Primary precipitation directly from normal seawater.
(B) The weathering of silicate minerals.
(C) The accumulation of dolomite-shelled organisms.
(D) The replacement of pre-existing calcite or aragonite.

280. Cross-bedding is a sedimentary structure that is formed by:
(A) The migration of ripples or dunes.
(B) The shrinkage of mud upon drying.
(C) The settling of sediment from a turbidity current.
(D) The burrowing activity of organisms.

281. In the context of diagenesis, what is 'cementation'?
(A) The physical squeezing of water out of sediment due to burial pressure.
(B) The dissolution of minerals to create pore space.
(C) The chemical precipitation of minerals into pore spaces, binding sediments together.
(D) The breaking of grains during transport.

282. Which of these environments is most likely to preserve large, delicate fossils?
(A) A quiet, anoxic, deep-water basin.
(B) A high-energy beach with strong wave action.
(C) A fast-flowing mountain river.
(D) A migrating sand dune in a desert.

283. The chemical stability of minerals at the Earth's surface is generally the inverse of:
(A) The Wentworth scale
(B) The Mohs hardness scale
(C) The geologic time scale
(D) Bowen's reaction series

284. Consider the following statements about granulometric analysis:
1. It is used to determine the mineral composition of sediments.
2. It involves measuring the grain size distribution of a clastic sediment.
3. Parameters like mean grain size and sorting are derived from this analysis.

Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

285. In Folk's limestone classification, a rock composed of more than 90% micrite (carbonate mud) is called a:
(A) Sparstone
(B) Oosparite
(C) Micrite
(D) Intramicrite

286. What is the key characteristic of a 'transitional' depositional environment?

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54. (B) Magmatic arc
The composition of a sandstone directly reflects its source area. A suite dominated by volcanic rock fragments, plagioclase feldspar, and pyroxene is diagnostic of a magmatic arc provenance. These minerals and fragments are typical products of the erosion of volcanic islands or continental volcanic arcs associated with subduction zones, rather than stable continental interiors or recycled mountain belts.

55. (D) An arid or semi-arid basin with high evaporation rates.
Evaporite minerals like halite and gypsum form through the precipitation of dissolved ions from water as it evaporates. This process requires a specific environment where evaporation exceeds freshwater input, typically in arid or semi-arid climates. Common settings include restricted marine basins, such as lagoons with limited ocean connection, or inland playa lakes where saline waters become increasingly concentrated.

56. (A) Both Statement I and Statement II are correct.
Lithification is the comprehensive term for the suite of processes that turn loose sediment into solid rock. Compaction and cementation are the most significant mechanisms involved. Compaction reduces the volume of the sediment by squeezing out fluids and closing pore spaces, while cementation involves the precipitation of minerals that bind the grains together into a coherent lithified mass.

57. (C) Chert
Sedimentary rocks are classified as clastic, chemical, or organic based on their origin. Chert is a primary example of a chemical sedimentary rock, composed of microcrystalline or cryptocrystalline silica. It can form through the inorganic precipitation of silica from groundwater or the accumulation of silica-rich skeletal remains. In contrast, conglomerate, sandstone, and shale are clastic rocks made of rock fragments.

58. (A) Saltation is the primary mode of transport for large boulders in a river.
Different grain sizes are transported by different mechanisms depending on fluid energy. While bedload involves traction and saltation, saltation is specifically the bouncing of sand-sized grains along the bed. Large boulders are too heavy for saltation; they move instead by traction, which involves rolling or sliding along the channel floor. Suspension is reserved for the finest particles like clay.

59. (D) Allochems and orthochems (micrite/sparite).
Folk's classification of limestones is based on two main components: allochems and orthochems. Allochems are the discrete grains like ooids, bioclasts, or intraclasts. Orthochems are the materials that fill the spaces between grains, namely micrite (fine-grained carbonate mud) and sparite (coarse-grained crystalline cement). The rock name is derived by combining the names of the dominant allochem and filling material.

60. (A) Both A and R are true and R is the correct explanation of A.
Aeolian (wind-blown) deposits are famously well-sorted. This is because wind is a highly selective agent of transport. For a given velocity, wind can only move a narrow range of particle sizes, typically fine to medium sand. Larger particles are left behind as lag, and finer particles are carried away in suspension, leaving a very uniform accumulation of sand grains.

61. (C) Poorly sorted
Sorting refers to the degree of uniformity in grain size within a sediment or sedimentary rock. A well-sorted sample has grains of nearly the same size. Conversely, a poorly sorted sample contains a wide range of particle sizes, from fine clay to coarse gravel. This texture typically indicates rapid deposition or a transport mechanism that does not effectively segregate particles by size.

62. (D) Density separation
Density separation is a laboratory technique used in sedimentology to isolate heavy minerals from lighter components like quartz and feldspar. By using a liquid with a high specific gravity, such as bromoform, the lighter minerals will float while the denser heavy minerals sink. This method is a crucial step in preparing samples for provenance analysis and heavy mineral identification.

63. (A) Glacial
Till is a characteristic deposit of glacial environments. It is formed by the direct deposition of material from melting ice without

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and abrasion. Breccias consist of angular clasts, which suggest minimal transport and that the sediment was deposited very close to its original source area before lithification.

118. (B) Delta
Transitional environments are located at the boundary between land and sea. A delta is a primary example, forming where a river enters the ocean. It combines fluvial processes with marine wave and tidal action. Fluvial, eolian, and lacustrine systems are all continental environments. Deltas serve as major sites for sediment accumulation and often contain important records of changing sea levels.

119. (A) Mean, sorting, skewness, and kurtosis.
Granulometric analysis involves the statistical study of grain size data. By plotting grain size distributions on histograms or cumulative frequency curves, geologists can calculate several key parameters. These include the mean, sorting, skewness, and kurtosis. These parameters are used to interpret the energy and transport history of the sediment, providing insights into the depositional environment and processes involved.

120. (A) P-3, Q-1, R-4, S-2
In sedimentary petrology, rocks are named based on their grain size and the processes they undergo. Arenites are rocks composed of sand-sized particles. Rudites consist of gravel-sized clasts. Argillites are made of mud-sized particles. Lithification is the overarching term for the physical and chemical processes, such as compaction and cementation, that transform loose sediment into solid, coherent sedimentary rock.

121. (C) Secondary porosity
Porosity in a sedimentary rock can be primary or secondary. Primary porosity exists at the time of deposition. Secondary porosity forms later during diagenesis. One common mechanism for creating secondary porosity is the dissolution of unstable grains, such as feldspar or carbonate fragments, by circulating pore fluids. This process removes mineral matter, creating new void spaces within the rock body.

122. (A) Diagenetic Overprint
Provenance analysis classifies source areas based on their tectonic setting. Standard types include Craton Interior, Magmatic Arc, and Recycled Orogen. Each of these settings produces sandstones with distinct mineralogical signatures. Diagenetic overprint is not a type of provenance; rather, it refers to the post-depositional alterations that can obscure the original provenance signal in a sedimentary rock after deposition.

123. (D) Quartz, Feldspar, and Lithic fragments.
The standard classification of sandstones is based on the relative abundance of three main framework components: Quartz, Feldspar, and Lithic fragments. These are often plotted on a ternary diagram known as the QFL diagram. This mineralogical classification provides essential information about the source area, transport history, and tectonic setting where the sediment originated, aiding in paleogeographic reconstruction.

124. (B) A low-energy, quiet-water environment with rapid burial.
The preservation of delicate fossils and the presence of fine-grained shale are indicators of specific environmental conditions. Such features suggest a low-energy, quiet-water environment where fine particles like clay can settle out of suspension. Rapid burial in these settings protects organic remains from scavenging and mechanical breakage, making environments like deep lakes or quiet lagoons excellent for preservation.

125. (C) Statement I is correct, but Statement II is incorrect.
Bedding is the most fundamental primary sedimentary structure. Bedding planes represent surfaces of non-deposition, erosion, or a change in the conditions of deposition, such as fluid velocity or sediment source. Because bedding forms during the accumulation of sediment, it is a primary structure rather than a secondary one formed during diagenesis. Statement II is therefore incorrect in its terminology.

126. (B) 2 and 3 only
Sediment transport involves several mechanisms. Suspension is the primary way that the finest particles, such as clay, move within a fluid. Traction involves the continuous rolling or

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grains. Shales are characterized by their fissility and are made of the finest particles, including silt and clay. This classification reflects the energy and distance of transport from the source.

73. (C) Sedimentary maturity
Sedimentary maturity is a measure of the extent to which a sediment has been modified by transport and weathering. As transport progresses, less stable minerals like feldspar are broken down and removed, leaving a sediment enriched in stable minerals like quartz. Higher maturity, both mineralogical and textural, indicates a more prolonged or intense history of environmental processing between source and deposition.

74. (C) Statement I is correct, but Statement II is incorrect.
Dolostone is a carbonate rock composed primarily of the mineral dolomite. While some dolomite can precipitate directly in rare modern environments, most ancient dolostones are believed to form through the diagenetic replacement of pre-existing limestone. This process, known as dolomitization, involves the exchange of calcium ions for magnesium ions in the carbonate crystal lattice, usually after the initial deposition.

75. (D) The dynamic viscosity of the fluid
Stoke's Law provides a mathematical framework for calculating the settling velocity of particles in a fluid. In the formula, the Greek letter mu represents the dynamic viscosity of the fluid. Viscosity measures the fluid's resistance to flow and internal friction. A higher viscosity results in a lower settling velocity because the fluid exerts a greater drag force against the moving sediment.

76. (B) A magma chamber
A depositional environment is a specific geographic setting where sediment accumulates. Common examples include river channels, desert dune fields, and the deep-sea floor. A magma chamber, however, is an underground reservoir of molten rock. While crystallization occurs there to form igneous rocks, it is not an environment where surface sediment is transported or deposited by water, wind, or ice.

77. (C) Load cast
Load casts are sedimentary structures that result from soft-sediment deformation shortly after deposition. They form when a denser layer, typically sand, is deposited over a less dense, water-saturated layer of mud. The weight of the sand causes it to sink into the underlying mud in irregular lobes. This process occurs before lithification, reflecting instability in the newly deposited sedimentary sequence.

78. (D) Litharenite
In the classification of sandstones, a Litharenite is a type of sandstone where the framework grains consist of a significant proportion of lithic fragments (rock fragments). Specifically, if these rock fragments make up more than twenty-five percent of the framework grains, the rock is classified as a litharenite. These rocks typically indicate a source area with a variety of exposed rock types.

79. (A) Shale
Fissility is the characteristic property of a rock to split easily along thin, closely spaced, parallel layers. This feature is most commonly associated with shale. It results from the parallel alignment of platy clay minerals during compaction. Fissility distinguishes shale from mudstone, which has a similar fine-grained composition but lacks the tendency to split into thin sheets, appearing blocky.

80. (A) Both A and R are true and R is the correct explanation of A.
Turbidites are sedimentary deposits formed by turbidity currents, which are high-density, gravity-driven flows of sediment and water. As a turbidity current slows down, it loses the energy required to transport sediment. The coarsest particles settle first, followed by progressively finer grains, resulting in the characteristic normally graded bedding that is used to identify ancient deep-sea fan deposits in basins.

81. (B) Sand
The naming of unconsolidated sediment is based on the dominant grain size fraction. In a sample composed of seventy percent sand, twenty percent silt, and ten percent clay, sand is the clearly dominant component. Therefore, the most appropriate general name for this sediment

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the influence of running water. As a result, till is extremely poorly sorted, containing a chaotic mixture of grain sizes ranging from microscopic clay to enormous boulders. This lack of sorting and stratification is a diagnostic feature of glacial deposits.

64. (B) It implies minimal transport from a nearby source area.
The shape of clasts provides evidence of their transport history. During transport, particles collide and experience abrasion, which smooths their edges and increases roundness. Highly angular clasts in a rock like breccia indicate that the sediment has undergone minimal transport. This suggests that the source of the material was very close to the final site of deposition.

65. (A) IV, II, I, III
A typical seaward progression of depositional environments begins at the coast. Behind a barrier beach, a lagoon may form. Moving seaward, the beach itself transitions into the shallow marine neritic zone on the continental shelf. Finally, the environment drops off into the deeper marine bathyal zone. Therefore, the land-to-sea sequence is lagoon, beach, neritic, and then bathyal offshore.

66. (A) Clay minerals
The term 'argillaceous' is used to describe sedimentary rocks that are rich in clay-sized particles and clay minerals. This group includes common rocks like shale, mudstone, and claystone. Argillaceous rocks are characterized by their fine-grained texture and are typically deposited in low-energy environments where fine particles can settle out of suspension, such as deep-sea floors or quiet lakes.

67. (C) During or very shortly after deposition.
Primary sedimentary structures are features that form during the process of deposition or very shortly thereafter, before the sediment becomes lithified. These structures, such as bedding, ripple marks, and cross-stratification, provide direct evidence of the physical and biological conditions present in the ancient environment. They are distinct from secondary structures that form much later during diagenesis or tectonic deformation.

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68. (D) A significant amount of feldspar (typically >25%).
In the classification of sandstones, an Arkose is a specific type defined by its mineralogical composition. It is a feldspar-rich sandstone, typically containing more than twenty-five percent feldspar grains. Arkoses often appear pinkish or reddish due to the high feldspar content and generally suggest a source area composed of granitic or gneissic rocks and a relatively short transport history.

69. (C) The velocity of the transporting fluid.
Sedimentation is a dynamic process controlled by several physical factors. One of the most critical is the velocity of the transporting fluid, whether it be water or wind. Fluid velocity determines the energy available to erode, transport, and eventually deposit sediment. When velocity drops below a certain threshold for a specific particle size, deposition occurs, directly influencing the resulting sequence.

70. (A) 1 and 2 only
Flute casts are erosional sedimentary structures found on the base of a bed, usually a sandstone. They are formed when turbulent currents scour the underlying mud surface, and the resulting depressions are later filled by sand. Flute casts are excellent palaeocurrent indicators, with the bulbous, rounded end pointing upstream and the flared, shallower end pointing downstream in the flow direction.

71. (D) Granulometry
Granulometry is the branch of sedimentology dedicated to the study and measurement of grain size distributions in sediments and sedimentary rocks. By performing granulometric analysis, geologists can determine statistical parameters such as mean size, sorting, and skewness. These data are used to interpret the transport mechanisms, energy levels, and depositional history of the clastic material being studied in detail.

72. (B) P-3, Q-4, R-1, S-2
Clastic rocks are classified based on the size and shape of their grains. Conglomerates contain rounded gravel-sized clasts, while breccias feature angular gravel-sized clasts. Sandstones are composed predominantly of sand-sized

91. (D) A decrease in fluid velocity below a critical threshold for a particle causes deposition.
There is a direct relationship between fluid velocity and the transport of sediment. Fluid velocity determines the energy available to keep particles in motion. For any given particle size, there is a critical threshold velocity required for transport. If the fluid velocity decreases below this specific threshold, the fluid can no longer support the particle's weight, leading to its deposition.

92. (B) Terrigenous (from land), biogenic (from organisms), and chemical (precipitates).
Sediments can be derived from several different sources. Terrigenous or clastic sediments originate from the weathering and erosion of pre-existing rocks on land. Biogenic sediments are formed from the remains of living organisms, such as shells and skeletons. Chemical sediments result from the direct precipitation of minerals from water. Most sedimentary deposits are a combination of these three primary origins.

93. (B) Both Statement I and Statement II are incorrect.
In sedimentology, texture and structure have specific meanings. Texture refers to the small-scale properties of the individual grains, including their size, shape, and arrangement. Structure refers to the larger-scale features of the rock body, such as bedding, ripple marks, and cross-stratification. The definitions provided in the statements are swapped, making both statements incorrect in their technical application to geology.

94. (D) Well-sorted sand, often with parallel lamination or low-angle cross-bedding.
Beach environments are high-energy coastal zones where wave action and tides constantly rework sediment. This process results in well-sorted sand because the energy is sufficient to remove fine silt and clay. Characteristic features include parallel lamination or low-angle cross-bedding formed as waves wash up and down the shore. This distinguishes beaches from glacial, deep marine, or evaporitic settings.

95. (A) Dolomitization
Dolomitization is a common diagenetic process in carbonate rocks. It involves the chemical replacement of primary calcium carbonate minerals, such as calcite or aragonite, with the mineral dolomite. This typically occurs when magnesium-rich fluids circulate through the rock. Because the dolomite crystal lattice is more compact than calcite, this process often creates secondary porosity, enhancing the rock's quality as a reservoir.

96. (C) P-4, Q-2, R-3, S-1
Sandstone classification is based on mineralogy and matrix. Quartz arenites are pure, containing over ninety-five percent quartz. Arkoses are defined by having more than twenty-five percent feldspar. Litharenites contain a high proportion of unstable rock fragments. Greywackes are distinguished by a high percentage of fine-grained clay matrix, reflecting a lack of sorting and immature composition during deposition.

97. (A) Psephitic (gravel)
Terminology for sediment size classes often uses synonymous terms from Greek and Latin roots. 'Rudaceous' is a term derived from Latin used to describe coarse-grained sedimentary rocks like conglomerates and breccias. It is synonymous with the Greek-derived term 'psephitic'. Both terms refer to the gravel-sized fraction of sediments, which includes particles larger than two millimeters in diameter.

98. (A) A burrow or trackway
Trace fossils, or ichnofossils, are a type of organic sedimentary structure that records the activity of organisms rather than their physical remains. A burrow or trackway is a classic example of a trace fossil. Unlike a preserved shell or bone, which are body fossils, a trace fossil provides evidence of how ancient animals moved, fed, or lived within the sediment.

99. (C) A transitional environment with shallow water separated from the sea by a barrier.
A lagoon is a transitional depositional environment consisting of a shallow body of water separated from the open sea by a barrier, such as a reef, sandbar, or island. Because they are protected from high-energy waves, lagoons are typically low-energy environments where fine-grained mud and silt accumulate. They can also become sites of evaporite formation if circulation is restricted.

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is sand. This classification system allows for a quick and standardized description of sediment composition in the field.

82. (A) To act as an index of mineralogical maturity of the sediment.
The ZTR Index is calculated from the percentages of the heavy minerals Zircon, Tourmaline, and Rutile. These three minerals are exceptionally resistant to both chemical weathering and mechanical abrasion. A high ZTR index indicates that the sediment is mineralogically very mature, meaning it has undergone extensive weathering or multiple cycles of transport and recycling, which removed less stable heavy minerals.

83. (C) A desert playa lake
Continental depositional environments are those located on land. A desert playa lake is a prime example. These are shallow, temporary lakes in arid basins that evaporate to leave behind fine-grained sediment and evaporite minerals. Unlike shelf, estuary, or reef environments, which are marine or transitional, a playa lake is entirely terrestrial and subject to the physical and chemical processes.

84. (D) Transport
Diagenesis refers to the processes that alter sediment after it has been deposited but before it reaches metamorphic conditions. This includes compaction, cementation, and dissolution within the buried layers. Transport is the physical movement of sediment from its source to the site of deposition. Because transport occurs before the sediment is deposited and buried, it is not considered part of diagenesis.

85. (C) Wackestone
Dunham's classification of limestones uses the ratio of grains to mud and the nature of the support. A wackestone is defined as a carbonate rock that is mud-supported, meaning the grains are not in continuous contact and float" in a muddy matrix. To be classified as a wackestone rather than a mudstone, the rock must contain more than ten percent grains.

86. (B) Stratigraphy
Stratigraphy is the branch of geology concerned with the study of rock layers, or strata. It involves the description, correlation, and interpretation of these layers to reconstruct the chronological sequence of geological events. Stratigraphy is essential for understanding the history of the Earth, the evolution of life through fossil records, and the spatial distribution of sedimentary bodies within a basin.

87. (D) Coal
Organic sedimentary rocks form from the accumulation and lithification of organic matter. Coal is the most significant example, formed from the buried remains of plant material, typically in swampy environments. Over geological time, heat and pressure drive off volatiles and concentrate carbon. This distinguishes coal from clastic rocks like sandstone or chemical precipitates like rock salt, which have inorganic origins.

88. (A) 1 and 2 only
Palaeocurrent analysis uses sedimentary structures to determine ancient flow directions. Asymmetrical ripple marks indicate the direction of the current, with the steeper face pointing downstream. In conglomerates, flat pebbles often dip upstream, a feature known as imbrication. This data is extremely useful for basin analysis, helping geologists map the drainage patterns and source directions of ancient sedimentary systems across regions.

89. (C) Limestone or Dolostone
Sedimentary rocks are categorized by their mineralogy when they are non-clastic. Rocks composed of more than fifty percent carbonate minerals, such as calcite or dolomite, are broadly classified as carbonate rocks. This group includes limestone, which is primarily calcium carbonate, and dolostone, which is magnesium-calcium carbonate. These rocks typically form in marine environments from biological activity or precipitation.

90. (B) II, III, IV, I
The stability of minerals at the Earth's surface follows a specific order known as the Goldich stability series. High-temperature minerals like olivine and pyroxene weather the fastest and are least stable. Muscovite mica is more resistant, and quartz is the most stable common rock-forming mineral. Therefore, the sequence of increasing stability is olivine, pyroxene, muscovite mica, and finally quartz.

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Therefore, diagenesis is a post-depositional study and is not part of provenance.

109. (C) Statement I is correct, but Statement II is incorrect.
Marine environments are classified by depth and distance from land. Shallow marine settings occur on the continental shelf, extending from the shore to the shelf break. Deep marine settings occur on the continental slope and abyssal plain. Therefore, while the shelf is a marine environment, it is categorized as shallow marine rather than deep marine, making the second statement incorrect.

110. (D) Transport over a distance by water, rounding clasts.
The formation of a conglomerate, which contains rounded gravel-sized clasts, provides evidence of its transport history. Roundness is achieved through abrasion as clasts collide and rub against each other during movement. Therefore, the presence of rounded pebbles indicates that the sediment was transported over some distance, typically by flowing water in a river or a high-energy beach environment during transport.

111. (A) Aeolian (desert)
Aeolian (desert) environments are characterized by wind-driven transport. Wind is a highly effective agent for producing well-sorted, fine-to-medium sand. The migration of large dunes in these settings creates large-scale cross-bedding within the sand deposits. These structures are often much larger than those formed by water currents and are a diagnostic feature for identifying ancient desert environments in the record.

112. (B) Map the trends of porous and permeable sand bodies (reservoirs).
In resource exploration, particularly for hydrocarbons, palaeocurrent analysis is a vital tool. By determining the direction of ancient currents, geologists can map the trends and geometry of sand bodies. Since these sand bodies often serve as reservoirs, understanding their orientation and connectivity is crucial for predicting where porous and permeable rocks are likely to be located within a basin.

113. (A) II, IV, I, III
The formation of a clastic sedimentary rock follows a specific chronological sequence. It begins with the weathering and erosion of pre-existing rocks to create sediment. This material is then transported by agents like water or wind. Eventually, the sediment is deposited in a basin. Over time, subsequent burial leads to lithification, which transforms the loose particles into solid rock.

114. (A) Tuff
Tuff is a type of volcanoclastic rock formed from the consolidation of volcanic ash. During an explosive eruption, fine particles of glass, crystals, and rock are ejected into the atmosphere and eventually settle to the ground. When these ash deposits are buried and undergo lithification, they become tuff. This distinguishes it from lava flows, which are solidified molten rock.

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115. (C) It involves physical, chemical, and biological processes that alter sediment after deposition.
Diagenesis is the term used for all the physical, chemical, and biological processes that alter a sediment after its initial deposition. These processes occur at relatively low temperatures and pressures compared to metamorphism. Diagenesis includes compaction, cementation, and mineral replacement, and it is responsible for the lithification of sediment into solid rock within a sedimentary basin after burial.

116. (A) Both A and R are true and R is the correct explanation of A.
Mineralogical maturity refers to the extent to which unstable minerals have been removed from a sediment. Quartz is chemically and physically very stable at the Earth's surface. Sandstones composed almost entirely of quartz are considered highly mature because extensive weathering and long transport distances selectively eliminate less stable minerals like feldspar, leaving behind a concentrated residue of resistant quartz grains.

117. (C) The angularity of the clasts.
Breccia and conglomerate are both coarse-grained clastic rocks containing gravel-sized clasts. The key feature that distinguishes them is the shape of the clasts. Conglomerates are characterized by rounded clasts, indicating significant transport

100. (A) Both A and R are true and R is the correct explanation of A.
Heavy minerals are powerful tools for provenance analysis because they occur in small quantities but provide unique diagnostic information. Specific assemblages of heavy minerals can be linked to particular types of source rock terranes, such as metamorphic belts or volcanic arcs. By identifying these suites, geologists can accurately reconstruct the source area and the tectonic history of the sediment.

101. (C) Grainstone
Dunham's classification focuses on the relationship between grains and matrix. A grainstone is a carbonate rock that is grain-supported and lacks a muddy matrix. This indicates a high-energy environment where any fine-grained carbonate mud was winnowed away by currents or waves. Grainstones often have high primary porosity, making them significant in the study of hydrocarbon reservoirs and aquifers.

102. (B) Dissolution
Weathering is the process of breaking down rock into sediment. Physical weathering involves mechanical processes like frost wedging, abrasion, and thermal expansion, which physically fragment the rock. Dissolution, however, is a process of chemical weathering where minerals are dissolved into solution by water. While it contributes to the generation of sediment components, it is not a physical weathering process.

103. (D) Sediments composed of fragments of volcanic origin.
Volcanoclastic sediment is composed of fragmental material produced by volcanic activity. This includes volcanic ash, individual crystals, and fragments of volcanic rock. These sediments can be deposited directly from an eruption or redistributed by water and wind. They are distinct from standard siliciclastic sediments because their source is specifically volcanic rather than result from general continental weathering and erosion.

104. (A) It reflects the transport mechanism, distance of transport, and depositional energy.
The texture of a sedimentary rock, including grain size, shape, and sorting, provides critical information about its history. It reflects the mechanism of transport, the distance the sediment traveled from its source, and the energy level of the depositional environment. Understanding texture allows geologists to reconstruct ancient physical conditions and dispersal patterns, although it does not provide absolute age data.

105. (D) 1, 2 and 3
Sedimentary rocks are classified into three broad groups based on their origin. Clastic rocks are composed of fragments and are classified primarily by grain size. Chemical rocks form through the precipitation of minerals from solution and are classified by their mineralogy. Organic rocks consist of the accumulated remains of living organisms. All three statements accurately describe these fundamental categories of sedimentary classification.

106. (A) The fine-grained carbonate mud matrix (<4 microns).
In Folk's classification of limestones, micrite refers to microcrystalline calcite. It is the fine-grained carbonate mud that forms the matrix in many limestones. Micrite consists of particles smaller than four microns in diameter and typically represents deposition in low-energy environments where fine material can settle. It is distinct from sparite, which is the coarser, crystalline cement that fills pore spaces.

107. (D) Flute cast
Sole marks are primary sedimentary structures found on the underside or bottom surface of a bed. They are often erosional features formed on a muddy surface and then cast in sand when a new layer is deposited. A flute cast is a classic example of a sole mark. Mud cracks and raindrop imprints form on top surfaces, and ripple marks are internal.

108. (B) The diagenetic history of the deposited sediment.
Provenance analysis focuses on understanding the origins of a sediment. This includes the composition of the parent rocks, the geographic location, tectonic setting, and the climatic conditions of the source area. Diagenetic history, however, refers to the changes that occur to the sediment after it has been deposited and buried.

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sliding of coarser grains along the bed. While Stoke's Law describes settling, it is only accurate for small particles in laminar conditions, not for large cobbles in turbulent flows. Thus, only statements.

127. (A) A surface of erosion or non-deposition, indicating a gap in the geologic record.
An unconformity is a significant surface in a stratigraphic sequence that represents a gap in the geologic record. This gap is caused by a period of erosion or a prolonged interval of non-deposition. Unconformities are essential for interpreting the history of a basin, as they indicate tectonic uplift, sea-level changes, or other events that interrupted continuous accumulation of sediment.

128. (B) Quartz
Quartz is the most common mineral found in sandstones globally. Its dominance is due to its high chemical and physical stability at the Earth's surface. While other minerals like feldspar or rock fragments may be present, they weather more easily. Quartz persists through multiple cycles of erosion and transport, making it the primary constituent of most mineralogically mature sandstones.

129. (B) Primary porosity
Primary porosity is the original pore space that exists between the grains of a sediment at the time it is deposited. It is a function of grain size, shape, and sorting. Over time, diagenetic processes like compaction and cementation typically reduce this initial porosity. Primary porosity is a critical factor in determining the initial fluid storage capacity of a sedimentary unit.

130. (A) An evaporite
Gypsum is a mineral that forms through the precipitation of dissolved salts from water as it evaporates. Rocks composed predominantly of gypsum or halite are classified as evaporites. These are chemical sedimentary rocks that provide important evidence of arid environmental conditions and restricted water circulation. They are distinct from clastic rocks like shale or conglomerate and from volcanoclastic deposits.

131. (C) Gradul settling of sediment from a waning current (e.g., turbidity).
Graded bedding is a sedimentary structure characterized by a systematic change in grain size within a single bed. It is most commonly formed by the gradual settling of sediment from a waning current. As a flow, such as a turbidity current, slows down, it loses the capacity to transport larger grains, which settle first, followed by progressively finer material.

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132. (D) Heavy mineral suites are often diagnostic of specific source rock types.
Heavy mineral analysis is a specialized technique in provenance studies. Heavy minerals, although rare, are highly significant because different suites are diagnostic of specific parent rock types. By identifying these minerals, geologists can fingerprint the source area. They are not the most abundant minerals, nor are they always unstable; in fact, many are exceptionally resistant to surface weathering processes.

133. (A) Both A and R are true and R is the correct explanation of A.
In a typical river system, there is a general decrease in sediment grain size in the downstream direction. This trend is driven by two main factors: mechanical abrasion, which physically breaks down particles as they travel, and the decreasing gradient of the river, which reduces flow velocity and its ability to transport larger, coarser material during transport events.

134. (B) A complex inter-fingering of fluvial channel sands, marsh peats, and marine muds.
Deltas are complex transitional environments formed where rivers meet the sea. They are characterized by a diverse range of sedimentary deposits that inter-finger as the delta progrades. This includes sands deposited in fluvial channels, fine-grained muds and organic-rich peats formed in marshes, and marine muds deposited in offshore areas, reflecting the interplay between land and marine processes.

135. (D) Low temperature and pressure, post-deposition but pre-metamorphism.
Diagenesis encompasses the various physical, chemical, and biological changes that occur to a sediment after it has been deposited. These changes take place under conditions of relatively

low temperature and pressure, occurring after deposition but before the higher-grade conditions of metamorphism are reached. It is distinct from surface weathering and the dynamic processes of erosion and sediment transport.

136. (A) Immature
Mineralogical or compositional maturity is determined by the abundance of stable minerals, primarily quartz. A rock containing only forty percent quartz along with significant amounts of unstable components like feldspar, mica, and rock fragments is considered compositionally immature. This suggests that the sediment has not undergone extensive weathering or long-distance transport that would typically remove these less resistant minerals.

137. (C) Ripple marks
Primary sedimentary structures are those that form during the process of deposition. Ripple marks are classic examples, created by the action of wind or water currents moving over a loose sediment bed. In contrast, stylolites, concretions, and joints are all features that develop after the sediment has been deposited and often after it has been lithified into rock.

138. (A) Shale is fissile (tends to split into thin layers), while mudstone is blocky.
Mudstone and shale are both fine-grained clastic sedimentary rocks composed of silt and clay. The defining difference between them is the presence of fissility. Shale is fissile, meaning it has the tendency to split easily along thin, closely spaced, parallel layers. Mudstone lacks this property and appears more blocky or massive. This distinction is visible in hand samples.

139. (D) Recycled orogen
Recycled orogen provenance refers to sediment derived from the erosion of uplifted mountain belts that consist of pre-existing sedimentary and low-grade metamorphic rocks. The resulting sandstones are typically characterized by an abundance of lithic fragments from these parent rocks, such as chert, siltstone, and phyllite. This provenance type is common in tectonic settings where continental crust is being deformed.

140. (A) II, IV, I, III
According to the Wentworth scale, clastic particles are classified by their diameter. Arranging them from smallest to largest size, clay is the finest fraction, followed by silt, then sand. Cobbles are much larger gravel-sized particles. Therefore, the correct ascending sequence is clay, silt, sand, and cobble. This standardized scale is essential for consistent communication in sedimentary petrology.

141. (C) Micrite and Sparite
Folk's classification of limestones uses a combination of the types of grains (allochems) and the material filling the spaces between them. The two main filling materials are micrite, which is fine-grained carbonate mud, and sparite, which is coarser-grained crystalline calcite cement. These represent different energy conditions, with micrite indicating quiet water and sparite indicating pore-filling crystalline cement.

142. (D) A prolonged and consistent process, such as wind or beach wave activity.
The degree of sorting in a sediment is an indicator of the consistency of the energy in the depositional environment. Very well-sorted sand with a symmetrical size distribution suggests a prolonged and consistent process that effectively segregates grains. Wind action in deserts or wave activity on beaches are prime examples of such persistent processes that produce exceptionally well-sorted deposits.

143. (A) Mechanical compaction of grains
As sediment is buried, the weight of the overlying material exerts pressure. This mechanical compaction causes grains to rearrange and pack more tightly, which leads to a direct and significant reduction in the rock's porosity. While dissolution can sometimes increase porosity, the physical process of compaction is the primary cause of porosity loss during early stages of burial and lithification.

144. (B) Glacial - Varves
Sedimentary environments are identified by their characteristic features. Fluvial systems have point bars, and eolian systems produce loess. Glacial environments are characterized by varves, which are annual layers of sediment in glacial lakes. Mud cracks, however, indicate subaerial exposure

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and are not typical of deep marine environments, which are permanently submerged and generally characterized by low-energy muddy deposition.

145. (C) P-4, Q-1, R-2, S-3
Diagenesis involves several distinct processes. Compaction is the reduction of volume due to pressure. Cementation is the precipitation of minerals that bind grains. Dissolution is the removal of mineral matter by fluids. Replacement occurs when one mineral dissolves and another takes its place, such as the conversion of calcite to dolomite. These processes collectively transform loose sediment into rock.

146. (A) Quartz Arenite
In the classification of sandstones, a quartz arenite is a rock where the framework is composed almost entirely of quartz grains. By definition, a sandstone with more than ninety-five percent quartz is classified as a quartz arenite. These rocks are mineralogically very mature, indicating an intense history of weathering and transport that has removed nearly all less stable minerals.

147. (C) Statement I is correct, but Statement II is incorrect.
The shape of a sedimentary grain, specifically its roundness and sphericity, provides clues about its history. Statement I is correct: these parameters reflect transport history. Statement II is incorrect because highly angular grains indicate a short transport history with little abrasion. Grains become more rounded, not more angular, as they undergo longer and more intensive abrasive transport.

148. (D) Weathering and erosion of pre-existing rocks.
The primary origin of most sedimentary material is the weathering and erosion of pre-existing rocks. This includes igneous, metamorphic, and even older sedimentary rocks. Physical and chemical weathering break down these parent rocks into fragments and ions, which are then transported and deposited as sediment. This process is a fundamental part of the Earth's rock cycle over time.

149. (C) A marine transgression (sea-level rise).
A fining-upward" sequence, where coarse sandstones are overlain by fine-grained shales, typically indicates a decrease in the energy of the depositional environment over time. In a coastal setting, this often signifies a marine transgression, where rising sea levels move the shoreline landward, bringing deeper, lower-energy marine environments over what were once higher-energy nearshore or terrestrial settings.

150. (B) 2 and 3 only
Evaporites are chemical sedimentary rocks, not clastic ones. They form through the precipitation of minerals from saline water as it evaporates, typically in restricted basins. Common minerals found in these deposits include gypsum and halite. Therefore, statements two and three are correct, as they accurately describe the formation process and common mineralogy of these distinct evaporite rocks.

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151. (D) They determine the geometry and trend of sand bodies, which control reservoir continuity.
In the assessment of hydrocarbon reservoirs, the study of palaeocurrents is critical for understanding the geometry and trend of sand bodies. Ancient current directions determined where sand was deposited and how those deposits are oriented. Since these sand bodies form the actual reservoir, knowing their trend helps geologists predict the continuity and connectivity of the reservoir across a basin.

152. (A) Stylolites
Stylolites are secondary sedimentary structures that form as a result of pressure solution. This process occurs during deep burial when the pressure from overlying rocks causes minerals to dissolve along irregular surfaces. Stylolites appear as jagged, zigzag lines in the rock and are common in carbonate rocks like limestone. They are not primary structures formed at the time of deposition.

153. (C) Facies
The term 'facies' refers to the overall characteristics of a sedimentary rock body that reflect its specific depositional environment. This includes the rock's lithology, texture, and sedimentary structures. By identifying different facies within a sequence, geologists can reconstruct the various environments that existed in an area over time and understand how these environments shifted geographically across space.

where fine clay minerals can slowly settle out of suspension during deposition.

228. (A) I, II, IV, III
Arranging depositional environments from the most landward to the most seaward position follows a logical geographic progression. An alluvial fan forms on land at the base of mountains. A delta forms at the shoreline where a river meets the sea. Moving offshore, the continental shelf is a shallow marine zone. Finally, the abyssal plain represents the deep ocean floor.

229. (C) A pyroclastic breccia
A rock composed of angular fragments of volcanic bombs, blocks, and lapilli is best described as a pyroclastic breccia. These fragments are ejected during explosive volcanic eruptions and accumulate near the vent. The angularity of the pieces and their volcanic origin distinguish this rock from standard conglomerates or bioclastic limestones, providing evidence of high-energy volcanic events in the geological record.

230. (B) Clastic and Chemical/Biochemical
Based on their origin, sedimentary rocks are broadly divided into two main categories: clastic (or siliciclastic) and chemical/biochemical. Clastic rocks form from the accumulation of fragments of pre-existing rocks. Chemical and biochemical rocks form from the precipitation of minerals from water or from the remains of living organisms. This fundamental division is the basis for most classification systems in petrology.

231. (D) Heavy mineral assemblages can be fingerprinted to specific source rock terranes.
Heavy mineral analysis is a powerful tool because different source rocks produce unique fingerprints" of heavy minerals. For example, a metamorphic source might yield kyanite, while a volcanic source yields chromite. By identifying these diagnostic assemblages, geologists can accurately link the sediment in a basin back to its specific source rock terrane, aiding in ancient paleogeographic reconstruction and tectonic studies.

232. (A) Larger, denser particles settle faster in a fluid than smaller, less dense particles.
The fundamental principle behind Stoke's Law of settling is that the velocity at which a particle falls through a fluid is determined by its size and density relative to the fluid. Specifically, larger and denser particles settle faster than smaller and less dense ones. This principle explains the sorting of sediments in quiet water environments where gravity is acting.

233. (C) Stromatolite
Organic sedimentary structures are those created by the biological activity of organisms. A stromatolite is a classic example, consisting of layered or mounded structures formed by the trapping and binding of sediment by microbial mats. Flute casts, load casts, and raindrop imprints are inorganic structures formed by physical or erosional processes rather than by living creatures or organisms.

234. (A) A higher percentage (>15%) of fine-grained matrix.
In sandstone classification, the primary feature that distinguishes a greywacke from an arenite is the proportion of fine-grained matrix. A greywacke contains a significant amount of matrix, typically more than fifteen percent, filling the spaces between sand grains. Arenites are clean" sandstones with very little matrix. This difference reflects the degree of sorting and energy in the depositional environment.

235. (D) Compaction and Cementation
Lithification is the conversion of loose sediment into solid rock. This transformation involves two main sub-processes: compaction and cementation. Compaction occurs as burial pressure squeezes the sediment, reducing its volume and porosity. Cementation follows as minerals precipitate from groundwater into the remaining pore spaces, binding the grains together. Together, these processes lithify the sediment during burial within a sedimentary basin.

236. (A) 1 and 2 only
Sedimentary textures provide clues about the history of a sediment. Sorting refers to the degree of uniformity in grain size. Roundness describes how much the sharp corners of a grain have been smoothed by abrasion. Well-rounded grains indicate extensive transport or reworking but not necessarily a volcanic origin. Therefore,

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163. (C) Replacement (recrystallization)
Replacement or recrystallization is a common diagenetic process. One classic example is the conversion of aragonite, a common but less stable form of calcium carbonate found in many shells, into calcite, which is a more stable polymorph. This change occurs after deposition as pore fluids interact with the shells, and it is a key part of diagenetic alteration.

164. (D) Oscillatory (back-and-forth) motion of waves.
Symmetrical ripple marks are primary sedimentary structures characterized by equal slopes on both sides. They are typically formed by the oscillatory, back-and-forth motion of waves in shallow water environments. This distinguishes them from asymmetrical ripples, which are formed by unidirectional currents like those found in rivers or wind-blown dunes, where one side is steeper than the other.

165. (C) Alluvial fan
Continental depositional environments are located on land. An alluvial fan is a classic example, consisting of a fan-shaped deposit of sediment formed where a high-gradient stream leaves a narrow mountain canyon and enters a broader, flatter valley. Estuaries, lagoons, and continental shelves are all considered transitional or marine environments because of their direct connection to the open sea.

166. (A) P-3, Q-4, R-2, S-1
Carbonate rocks contain various grain types. Ooids are spherical, concentrically coated grains. Bioclasts are fragments of shells or skeletons. Intraclasts are reworked pieces of semi-consolidated carbonate mud. Peloids are typically fecal pellets or other micritized grains of uncertain origin. Matching these descriptions is fundamental to the detailed petrographic classification of limestones using standard systems like Folk's or Dunham's.

167. (D) Diagenesis
The process of cementation occurs after sediment has been deposited and buried. It involves the precipitation of minerals, such as calcite or silica, in the pore spaces between grains. This is a core part of diagenesis, the suite of changes that turn loose sediment into rock. The reaction of a sandstone with acid due to calcite cement is evidence of this diagenetic history.

168. (A) Sedimentology
Sedimentology is the branch of geology that studies the properties, classification, and origin of sedimentary rocks. A central theme of this field is the relationship between sedimentary facies—the specific characteristics of a rock body—and the depositional environments in which they formed. This study allows geologists to reconstruct ancient landscapes and understand the history of Earth's surface processes.

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169. (C) Unstable minerals indicate short transport distances and/or arid climates.
Mineral stability is a key factor in provenance analysis because it relates to the history of weathering and transport. The presence of chemically unstable minerals, such as olivine or certain feldspars, suggests that the sediment has not undergone intensive weathering. This often indicates a short transport distance from the source or a climate where chemical weathering rates were low.

170. (A) I, III, II
Diagenesis is often divided into stages based on depth and timing. Eogenesis refers to the early changes that occur during shallow burial. Mesogenesis includes the processes that take place during deeper burial at higher temperatures and pressures. Telogenesis occurs much later when the sedimentary rock is uplifted and subjected to weathering and interaction with meteoric waters near the surface.

171. (D) Volcanic lithic fragments, plagioclase, and pyroxene.
Sandstones derived from a magmatic arc provenance have a very specific composition. They are rich in volcanic lithic fragments, plagioclase feldspar, and ferromagnesian minerals like pyroxene. This suite of minerals and fragments is characteristic of the erosion of volcanic chains associated with subduction zones, providing a clear mineralogical signal of the tectonic setting of the source area.

172. (B) Sorting
In granulometric analysis, several textural parameters are calculated to describe a sediment.

two millimeters in diameter. Common examples of rudites include conglomerates, which have rounded clasts, and breccias, which have angular clasts. These rocks reflect high-energy environments capable of transporting large fragments.

210. (A) Derivation from a granitic or gneissic source rock with rapid erosion and burial.
In provenance analysis, an abundance of feldspar grains in a sandstone typically suggests a source area composed of granitic or gneissic rocks. Because feldspar is chemically less stable than quartz, its presence in high quantities also implies rapid erosion and burial or a climate that limited chemical weathering, preventing the feldspar from being broken down into clay.

211. (C) Travertine
Travertine is a type of chemical sedimentary rock. It forms by the precipitation of calcium carbonate from mineral springs, especially hot springs. Unlike clastic rocks like sandstone or conglomerate which are made of rock fragments, or shales made of mud, travertine is a chemical precipitate that often has a banded or porous appearance due to its rapid formation.

212. (D) A progressive decrease in depositional energy or a transgression.
A fining-upward sequence, where the grain size of sediments decreases from the bottom to the top of a layer or sequence, generally indicates a progressive decrease in the energy of the depositional environment. This can happen as a current wanes, or in a larger stratigraphic sense, during a marine transgression where deeper, lower-energy water environments move over shallower ones.

213. (B) P-3, Q-4, R-1, S-2
Different structures provide unique palaeocurrent information. Asymmetrical ripples have a steeper face pointing downstream. In conglomerates, imbricated clasts dip upstream. Flute casts are erosional scours formed by currents like turbidites. Cross-bedding consists of foreset layers that dip in the direction of current flow. Matching these features is essential for reconstructing ancient drainage systems and dispersal patterns in a basin.

214. (B) Olivine
According to the Goldich stability series, which mirrors Bowen's reaction series, the stability of minerals at the Earth's surface is related to their formation temperature. Olivine, which crystallizes at very high temperatures, is the most chemically unstable of the common rock-forming minerals when exposed to surface conditions. It weathers rapidly into clay minerals compared to stable minerals like quartz.

215. (A) 1 and 2 only
Lithification is the process of turning loose sediment into solid rock, primarily through compaction and cementation. Diagenesis is a broader term that includes lithification as well as all other physical and chemical changes that occur after deposition. Compaction reduces, rather than increases, the porosity of a sediment as grains are squeezed together. Therefore, only statements one and two are correct.

216. (A) Coal
Coal is a unique sedimentary rock formed from the accumulation and preservation of plant material in oxygen-poor, swampy environments. Over time, heat and pressure from burial transform the organic matter into carbon-rich coal. This distinguishes it from carbonate rocks like limestone or clastic rocks like sandstone, which are formed from mineral fragments or chemical precipitates from water solutions.

217. (C) Compositionally mature to supermature, dominated by well-rounded quartz grains.
A 'craton interior' provenance refers to a source area located within a stable continental block. Because these areas are tectonically quiet, sediments often undergo prolonged weathering and multiple cycles of transport and recycling. This results in sandstones that are mineralogically very mature to supermature, being dominated by well-rounded and resistant quartz grains with almost no unstable mineral fragments.

218. (A) Depositional texture
Dunham's classification is a widely used system for limestones that focuses on depositional texture. It categorizes carbonate rocks based on the relationship between the grains and the mud matrix, and whether the framework is grain-supported or mud-supported. This approach

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laminar flow at keeping sediment in suspension and eroding the bed. It is the dominant flow regime in most rivers and high-energy currents.

182. (B) Greywacke
In the classification of sandstones, a greywacke is defined as a rock containing a high proportion of fine-grained matrix, typically more than fifteen percent. It is a mixture of sand, silt, and clay-sized particles and often contains unstable mineral and rock fragments. This high matrix content and immature composition distinguish it from 'clean' sandstones like quartz arenite or arkose.

183. (D) Statement I is incorrect, but Statement II is correct.
The ZTR Index, which stands for Zircon-Tourmaline-Rutile, is a specific metric used in heavy mineral analysis. These three minerals are extremely resistant to weathering and abrasion. Therefore, a high ZTR index is used as a reliable indicator of the mineralogical maturity of a clastic sediment, rather than its tectonic provenance. It shows how much the sediment has been processed.

184. (A) A meandering fluvial system
A point bar is a depositional feature that forms on the inside curve of a meandering river. As the current slows down on the inner bank, it deposits sediment, typically sand and gravel, creating a crescent-shaped bar. Point bars are classic indicators of fluvial environments and their migration contributes to the characteristic lateral accretion surfaces seen in ancient river deposits.

185. (C) The source area from which the sediment was derived.
Provenance is a fundamental concept in sedimentology that specifically refers to the source area from which a sediment was derived. Analysis of provenance aims to identify the parent rock types and the geographic and tectonic origin of the sedimentary particles. This information is used to reconstruct ancient paleogeography and the history of erosion and sediment dispersal across regions.

186. (A) A restricted basin in an arid climate.
Halite, or rock salt, is an evaporite mineral. Its formation occurs in environments where the evaporation of saline water is the dominant process, causing the concentration of dissolved ions to reach the point of precipitation. This typically happens in restricted marine basins or inland lakes within arid climates. It does not form in high-energy rivers, deep trenches, or glacial settings.

187. (D) Conglomerate
Sedimentary rocks are divided into clastic, chemical, and organic types. A conglomerate is a classic example of a clastic rock because it is composed of fragments, or clasts, of pre-existing rocks that have been transported and deposited. Limestone, gypsum, and chert are typically chemical or biochemical in origin, formed by precipitation or biological activity rather than from fragments of pre-existing rocks.

188. (B) In the upstream direction.
Imbrication is a sedimentary structure where flat pebbles or clasts in a conglomerate are stacked like shingles. These clasts typically dip in the upstream direction, meaning they tilt toward the direction from which the current was flowing. This orientation is a very reliable palaeocurrent indicator, allowing geologists to determine the ancient flow direction of rivers and high-energy water systems.

189. (C) Increasing degree of sorting and grain roundness.
Textural maturity is a measure of the physical processing a sediment has undergone. It increases as the sediment becomes better sorted and the individual grains become more rounded. These changes occur as a result of prolonged transport and abrasion. High textural maturity typically suggests that the sediment has traveled a great distance from its source or has been extensively reworked over time.

190. (A) P-3, Q-4, R-1, S-2
Sedimentary rocks are classified by their origin. Sandstones are clastic rocks made of rock fragments. Limestones are carbonate rocks, often biochemical in origin. Rock salt is a chemical precipitate known as an evaporite. Coal is an organic rock formed from accumulated plant material. Correctly matching these rock types to their general classifications is a basic step in sedimentary petrology.

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Sorting is the parameter that measures the degree of uniformity or variation in grain size within a sample. A well-sorted sediment has grains of a similar size, while a poorly sorted one has a wide range of sizes. This information is vital for interpreting energy in ancient depositional media.

173. (C) Evaporite - Greywacke
Standard terminology classifies rocks by origin and grain size. Rudites are conglomerates, and arenites are sandstones. Argillites are shales. These are all clastic rocks. An evaporite is a chemical sedimentary rock formed by precipitation. A greywacke is a type of clastic sandstone with a high matrix content. Therefore, pairing 'evaporite' with 'greywacke' is incorrect as they represent different rock categories.

174. (B) 2 and 3 only
Lithification is the geological process that transforms loose, unconsolidated sediment into coherent sedimentary rock. It involves more than just physical compaction. Cementation, the chemical precipitation of minerals in pore spaces, is a critical second component. Together, compaction and cementation reduce porosity and bind the grains, completing the transition from sediment to solid rock during deep burial and diagenesis.

175. (A) Fragments of pre-existing rocks.
The term 'clastic' comes from the Greek word for 'broken'. In sedimentology, clastic rocks are those composed primarily of fragments or 'clasts' of pre-existing rocks. These fragments are produced by weathering and then transported and deposited. This group includes common rocks like conglomerate, sandstone, and shale, distinguishing them from chemical precipitates or rocks made of accumulated organic remains.

176. (B) Geode
Primary structures form during deposition. Secondary structures form later during diagenesis through chemical or physical changes. A geode is an example of a secondary structure; it is a hollow, often rounded rock cavity lined with crystals that precipitated from mineral-rich fluids after the surrounding rock was formed. In contrast, lamination, cross-bedding, and graded bedding are all primary sedimentary features.

177. (B) Phanerocrystalline
The classification of dolomite often uses terms that describe the size of its crystals. A dolomite with large crystals that are clearly visible to the naked eye or under low magnification is called phanerocrystalline. This is in contrast to aphanocrystalline or microcrystalline dolomites, where the crystals are too small to be seen individually. These textural differences reflect conditions of dolomitization.

178. (A) Geographic location relative to the shoreline.
Depositional environments are broadly categorized based on their geographic location relative to the shoreline. Continental environments are located inland, marine environments are in the ocean, and transitional environments occur exactly at the interface. This location determines the primary physical and chemical processes, such as the influence of tides, waves, or purely terrestrial river and wind action during sediment accumulation.

179. (A) Both A and R are true and R is the correct explanation of A.
Mud cracks are valuable sedimentary structures for environmental interpretation. They form when fine-grained sediment, such as clay, dries out and shrinks, creating a network of polygonal cracks. Because this drying requires the sediment to be out of the water, mud cracks serve as clear evidence of periodic subaerial exposure and desiccation in ancient depositional settings during formation.

180. (D) Have a higher specific gravity than the liquid, causing them to sink.
The laboratory separation of heavy minerals from light minerals like quartz and feldspar is based on their physical properties. Heavy minerals, as the name implies, have a significantly higher specific gravity. When a sample is placed in a high-density liquid like bromoform, the denser heavy minerals sink to the bottom while the lighter minerals float, allowing for effective isolation.

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181. (C) Turbulent flow
Fluid flow in sedimentation is either laminar or turbulent. Turbulent flow is characterized by chaotic, irregular particle movement with eddies and vortices. This type of flow occurs at higher velocities and is much more effective than

200. (C) A is true but R is false.
Stylolites are irregular, jagged surfaces found within some sedimentary rocks, especially limestones. They form through the chemical process of pressure solution, where minerals dissolve at the contacts between grains under high burial pressure. Because this happens long after the sediment is deposited and buried, stylolites are secondary features rather than primary sedimentary structures. Statement II is therefore incorrect.

201. (C) Diagenesis
Diagenesis is the collective term for all the physical, chemical, and biological processes that alter a sediment after it has been deposited. This includes everything from the early stages of compaction and cementation to more complex mineral replacements and dissolutions that occur during burial. Diagenesis stops where metamorphism begins, and it is the process responsible for turning loose sediment into rock.

202. (A) Ash fall deposit (tuff)
Volcanoclastic sediments are those composed of fragments produced during volcanic activity. An ash fall deposit, which can lithify into a rock called tuff, is a primary example. Unlike limestone, rock salt, or river sand, which have biological, chemical, or general erosional origins, ash fall deposits are directly linked to the explosive ejection of material from a volcanic vent.

203. (D) Statement I is incorrect, but Statement II is correct.
Palaeocurrent analysis is of great significance in reservoir quality assessment. The direction of ancient currents determines the orientation and trend of sand bodies. Since these sand bodies often act as reservoirs for water or hydrocarbons, understanding their geometry and connectivity is essential for predicting the distribution of porous and permeable zones. Statement I is incorrect, while statement II is correct.

204. (B) Quartz, Feldspar, Rock Fragments
The mineralogical classification of sandstones is based on the relative proportions of three main framework components: Quartz, Feldspar, and Rock Fragments. These three types are often plotted on a ternary diagram to distinguish between quartz arenites, arkoses, and litharenites. This classification provides immediate information about the source rock composition and the degree of weathering and transport history.

205. (C) Saltation
Saltation is a mode of sediment transport where grains, typically sand-sized, move in a series of bounces and hops along the bed. This occurs when the lift and drag forces of the fluid are sufficient to temporarily suspend a grain, but it eventually falls back to the bed. This process is common in both river beds and desert dune environments.

206. (D) Deep marine
A turbidite is a distinctive sedimentary deposit formed by a turbidity current, which is a gravity-driven flow of sediment-laden water. Turbidites are most characteristic of deep marine environments, particularly on submarine fans at the base of the continental slope. They are characterized by graded bedding and a specific sequence of internal structures known as the Bouma sequence.

207. (A) Beach
Transitional environments are those located at the boundary between land and sea. A beach is a prime example, where terrestrial sediment meets marine wave and tidal processes. Alluvial fans and deserts are continental environments, and the deep sea is a marine environment. Beaches are characterized by high-energy wave action that effectively sorts sand and creates distinct sedimentary structures.

208. (B) Determine the distribution of its particle sizes.
The primary purpose of granulometric analysis is to measure the distribution of particle sizes within a clastic sediment sample. By quantifying the proportions of sand, silt, and clay, and calculating statistical parameters like sorting and skewness, geologists can gain insights into the energy of the depositional medium and the transport history of the sediment.

209. (B) Gravel
In the classification of clastic rocks, a rudite is a rock where the dominant grains are in the gravel size range. This means the clasts are larger than

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191. (A) Sand
The term 'arenaceous' is used in sedimentology to describe a sediment or sedimentary rock that has a grain size corresponding to sand. In the standard classification, this means the particles range between one-sixteenth of a millimeter and two millimeters in diameter. Sandstones are the most common arenaceous rocks, and the term implies a specific range of transport and energy conditions.

192. (C) IV, III, II, I
A logical order for a provenance study begins in the field with sampling. Back in the laboratory, petrographic analysis of the grain composition is performed. If needed, heavy minerals are separated for detailed study. Finally, all the data are integrated to interpret the parent rock types and the location of the source area. This sequence moves from observation to specialized analysis.

193. (B) Sediments can be derived from igneous, metamorphic, and pre-existing sedimentary rocks.
Sediments can originate from a variety of sources. They are primarily derived from the weathering and erosion of pre-existing rocks, which can be igneous, metamorphic, or even older sedimentary rocks. This recycled nature of sedimentary material is a key part of the Earth's rock cycle. While chemical precipitation also produces sediment, the majority of terrigenous material comes from pre-existing crustal rocks.

194. (A) Compaction
Compaction is a physical process that occurs as sediment is buried under subsequent layers. The increasing pressure from the overlying material squeezes the grains closer together, which reduces the amount of pore space and expels water. Compaction is the first major step in the lithification of sediment, leading to a reduction in volume and an increase in the density of deposits.

195. (D) 1, 2 and 3
Depositional environments are defined by the primary agents of transport and deposition. Fluvial environments are dominated by rivers and streams. Lacustrine environments refer to lakes. Aeolian environments are shaped by the action of the wind. All three statements correctly identify these standard categories, which are essential for geologists attempting to reconstruct ancient surface conditions and landscapes on the ancient Earth.

196. (D) The original components were bound together during deposition.
In Dunham's classification of carbonate rocks, a boundstone is a rock where the original components were bound together during the time of deposition. This typically occurs through the activity of organisms, such as in a coral reef or a microbial mat. The biological framework or binding distinguishes boundstones from rocks where grains were simply deposited as loose particles in mud.

197. (C) Cleavage
Primary sedimentary structures like bedding, ripple marks, and graded bedding form during or immediately after deposition. They provide evidence of the sedimentary processes. Cleavage, however, is a secondary structure that forms long after deposition, usually during tectonic deformation or metamorphism. It refers to the tendency of a rock to split along parallel planes of weakness caused by tectonic pressure.

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198. (B) Duration and intensity of transport abrasion.
The roundness of grains in a clastic rock is a measure of how smooth the edges and corners have become. This textural feature indicates the duration and intensity of abrasion during transport. As grains are moved by water or wind, they collide with each other, gradually wearing down sharp edges. Therefore, well-rounded grains suggest long transport history or high-energy reworking.

199. (D) Low-energy, fine-grained sediments like mud and silt.
A lagoon is a low-energy transitional environment protected from the open sea by a barrier. Because of the quiet water conditions, fine-grained sediments like mud and silt are the dominant deposits. High-energy coarse-grained material, glacial deposits, or large desert dunes are not characteristic of lagoons. Instead, lagoons are sites where fine sediment and sometimes organic or chemical precipitates accumulate.

provides immediate insights into the energy and environmental conditions present during the accumulation of the carbonate sediment in an ancient environment.

219. (D) Cementation
Cementation is a fundamental diagenetic process in the formation of sedimentary rocks. It involves the chemical precipitation of new minerals, such as calcite, silica, or iron oxides, within the pore spaces of a sediment. These minerals act as a natural glue, binding the individual grains together and transforming the loose material into a solid, lithified rock over time.

220. (D) Statement I is incorrect, but Statement II is correct.
Evaporites are chemical sedimentary rocks, not clastic ones. They form through the precipitation of minerals from a concentrated aqueous solution when evaporation exceeds water input. Common evaporite minerals include gypsum and halite. Therefore, statement I is incorrect because evaporites are not wind-transported clastic sediments, while statement II is correct in describing their chemical origin and formation process.

221. (C) Transitional environment.
An estuary is a transitional depositional environment located where a river meets the sea. It is characterized by the mixing of fresh river water and saline ocean water. Estuaries are influenced by both fluvial and marine processes, such as river flow and tidal action. This makes them distinct from purely continental or purely marine settings in their sedimentological properties.

222. (D) Transport and depositional history of the sediment.
The texture of a sedimentary rock, which includes grain size, sorting, and shape, is genetically significant because it records the history of the sediment. It provides direct clues about the mechanism of transport, the duration and distance of movement, and the energy level of the depositional environment. Texture is a primary tool for reconstructing ancient physical conditions on Earth's surface.

223. (A) Dolostone
While 'dolomite' is the name of a specific carbonate mineral, the sedimentary rock composed predominantly of that mineral is more formally called dolostone. This terminology helps distinguish between the mineral itself and the lithified rock body. Dolostones typically form through the replacement of limestone, and they are important reservoirs for groundwater and petroleum in many geological basins worldwide.

224. (B) Graded bedding
Primary sedimentary structures that indicate the 'up' direction in a stratigraphic sequence are known as geopetal indicators. Graded bedding is a classic example; in normal grading, the coarser particles are at the bottom and the finer ones are at the top. This pattern allows geologists to determine if a sequence of rocks is in its original orientation or overturned.

225. (A) Both A and R are true and R is the correct explanation of A.
In a stable cratonic setting, sandstones are often mineralogically mature, meaning they are rich in stable quartz. This occurs because the tectonic stability of the region allows for long periods of weathering and transport. These processes selectively break down and remove less stable minerals like feldspar, leaving behind a concentrated residue of resistant grains. Both assertion and reason are true.

226. (A) Hydrolysis
The formation of sediment involves physical and chemical processes. Physical processes like frost action, abrasion, and thermal expansion mechanically break rock into fragments. Hydrolysis, however, is a chemical weathering process where minerals react with water to form new minerals, such as the alteration of feldspar into clay. While it generates sediment components, it is not a physical process.

227. (C) Claystone or Shale
A rock made of lithified clay is called claystone or, if it is fissile and splits into thin layers, shale. These fine-grained rocks are composed of particles too small to be seen without a microscope. They typically form in low-energy environments like deep-sea floors or quiet lakes

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154. (A) Conglomerate
A conglomerate is a clastic sedimentary rock composed of rounded, gravel-sized clasts, such as pebbles and cobbles, that have been cemented together. The roundness of the clasts is a diagnostic feature indicating significant transport by water. This distinguishes it from a breccia, which contains angular fragments, and from finer-grained rocks like sandstone or shale in the sequence.

155. (A) Both A and R are true and R is the correct explanation of A.
Heavy mineral separation is a standard procedure in provenance analysis because certain heavy minerals are exceptionally durable. Minerals such as zircon, tourmaline, and rutile are highly resistant to both chemical weathering and physical abrasion. Their ability to survive multiple cycles of erosion and redeposition allows them to serve as reliable indicators of the original source rock types.

156. (B) Silt and clay-sized particles.
In the standard classification of common sediments and sedimentary rocks, 'argillites' refer to those composed predominantly of the finest particles. This includes both silt-sized and clay-sized particles. Argillites are the lithified equivalents of mud. They are distinct from arenites, which are sand-rich, and rudites, which are dominated by coarse gravel-sized clasts larger than two millimeters in diameter.

157. (C) Metamorphism of sedimentary rock
The process of sedimentation includes the erosion of a source rock, the transport of the resulting particles, and their eventual deposition in a basin. Lithification is also often associated with the later stages of this process. Metamorphism, however, involves the transformation of rocks under high temperature and pressure conditions and is a separate geological process that occurs after sedimentation.

158. (D) Grainstone
Dunham's classification distinguishes carbonate rocks based on their support and the presence of mud. A limestone that is grain-supported and contains carbonate mud is classified as a packstone. If it were grain-supported but lacked any mud matrix, it would be called a grainstone. Both represent higher-energy environments than mud-supported rocks like mudstones and wackestones during carbonate sediment accumulation.

159. (A) A lake
A lacustrine environment refers specifically to a depositional setting within a lake. These environments can range from shallow nearshore areas to deep offshore basins. Lacustrine sediments often include fine-grained muds, silts, and sometimes evaporites or carbonates, providing a record of the hydrological and climatic history of the terrestrial region where the lake is situated over geological time.

160. (B) The conditions of transport and deposition, such as current direction and flow regime.
The study of sedimentary structures is essential for understanding the physical conditions present during deposition. Features like cross-bedding, ripple marks, and flute casts provide direct evidence of the transport mechanism, current direction, and flow regime. While they do not give absolute ages, they are the primary tools for reconstructing ancient environmental settings and the dynamics of sedimentary processes.

161. (B) Sedimentary and low-grade metamorphic rock fragments.
A 'recycled orogen' provenance occurs when sediment is derived from the uplift and erosion of older sedimentary and low-grade metamorphic rocks. Consequently, the resulting sandstones are characterized by an abundance of lithic fragments from these parent rocks, such as chert, siltstone, and phyllite. This distinguishes them from sediments derived from volcanic arcs or stable cratonic interiors in tectonic settings.

162. (A) Both Statement I and Statement II are correct.
Granulometric analysis is a vital tool for studying the texture of clastic rocks. One of the most important parameters it provides is sorting, which measures the uniformity of grain sizes. The degree of sorting in a sediment is a direct reflection of the variation in energy within the depositing medium. Well-sorted sediments indicate a consistent energy level over time.

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only statements one and two are correct in their general application.

237. (C) Aeolian
An aeolian environment is characterized by well-sorted, fine-to-medium sand. The selectivity of wind as a transport agent effectively removes silt and clay. The migration of dunes in these settings often creates large-scale cross-bedding. Because deserts are harsh environments, fossils are typically absent. These features combined are diagnostic of ancient aeolian deposits in the stratigraphic record during geological analysis.

238. (A) Both Statement I and Statement II are correct.
Sedimentary structures are classified by the timing of their formation. Primary structures, like bedding and ripple marks, form at the time of deposition and reflect the conditions of the transport medium. Secondary structures, such as concretions or stylolites, form after deposition during the diagenetic stages of burial and lithification. Both statements correctly define these fundamental categories for sedimentary rock study.

239. (A) Clay and silt particles
The term 'argillite' refers to a fine-grained clastic sedimentary rock that has been lithified. It is primarily composed of particles in the clay and silt size ranges. Unlike shale, it does not necessarily show fissility. Argillites represent the consolidation of mud and are typical of low-energy depositional environments where the finest material can slowly accumulate and undergo burial over time.

240. (B) Shallow Marine
The continental shelf is the submerged edge of a continent that extends from the shoreline to the shelf break. It is part of the shallow marine environment category. The shelf is a major site for sediment accumulation and is influenced by wave action, tides, and ocean currents. It is distinct from purely continental environments and deeper marine settings like the abyssal plain.

241. (B) Grain-supported, composed of skeletal fragments, and cemented by sparry calcite.
In Folk's classification of limestones, a biosparite is a rock where the allochems are skeletal or fossil fragments and the filling material is sparry calcite cement. This indicates a grain-supported rock where the spaces between the fossils were filled by crystalline cement rather than carbonate mud, reflecting a relatively high-energy depositional environment where fine mud was winnowed away by currents.

242. (A) Medium- to high-grade metamorphic rocks.
Heavy minerals provide direct clues about the parent rocks of a sediment. The presence of kyanite, sillimanite, and staurolite in a heavy mineral suite is strongly diagnostic of a source area composed of medium- to high-grade metamorphic rocks. These minerals form under specific high-pressure and temperature conditions and their survival in sediment identifies the erosion of a metamorphic belt.

243. (C) During diagenesis.
Concretions are secondary sedimentary structures that form through the localized chemical precipitation of mineral cement in the pore spaces of a sediment. This process occurs during diagenesis after the sediment has been deposited and buried. Concretions grow outward from a nucleus and are typically harder and more resistant than the surrounding rock matrix, often weathering out as distinct, rounded rock masses.

244. (C) P-3, Q-1, R-4, S-2
Different terms describe how sediment moves and changes. Saltation is the bouncing of grains along a bed. Suspension involves the finest particles moving within the fluid. Traction refers to the rolling or sliding of the coarsest particles. Lithification is the process of converting loose sediment into solid rock. Correctly matching these terms to their descriptions is essential for understanding the sedimentary cycle.

245. (C) Glacial lake (lacustrine)
Varves are a distinctive type of sedimentary deposit characteristic of glacial lakes. They consist of annual couplets of thin layers: a thicker, coarser, light-colored layer deposited during the summer melt season, and a thinner, finer, dark-colored layer of clay that settles out during the winter when the lake is frozen. Varves are excellent records of seasonal climate and glacial activity over time.

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264. (A) III, II, IV, I
The chronological formation of a sedimentary rock begins with the weathering of parent rocks. The resulting sediment is then transported by agents like water or wind. Eventually, the sediment is deposited in a basin. Over time, as it is buried, the process of cementation binds the grains together into solid rock. Therefore, the correct order is weathering, transport, deposition, and cementation.

265. (C) Specific mineral suites can be linked to specific source rock types.
Heavy minerals are valuable in provenance analysis because specific assemblages of these minerals are characteristic of particular parent rock types. By identifying a suite of heavy minerals in a sandstone, geologists can 'fingerprint' the source area. While they are not the most abundant minerals, their diagnostic value for determining the lithology of the source area is exceptionally high for geologists.

266. (A) Graded bedding
In a stratigraphic sequence, determining the original 'up' direction is crucial. Graded bedding is one of the most reliable primary structures for this purpose. Normal grading, where grain size decreases from the bottom to the top of a bed, indicates that the finer material settled last. This allows geologists to identify the original orientation of beds even in tectonically deformed areas.

267. (D) Oosparite
In Folk's limestone classification, an oosparite is a rock where the primary grains are ooids and the material filling the pore spaces is sparry calcite cement. This indicates a grain-supported rock formed in a high-energy environment where carbonate mud was absent or winnowed away, allowing crystalline cement to fill the voids between the concentrically layered ooids during diagenesis.

268. (B) Suspension
The primary mechanism for the transport of the finest sediment particles, such as clay and fine silt, in a river is suspension. Because these particles are very small and light, the turbulence of the water is sufficient to keep them from settling. They move along with the main body of the flow, rather than rolling on the bed or bouncing via saltation.

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269. (C) They show the direction from which sediment was transported into a basin.
The study of palaeocurrents is significant because it allows geologists to reconstruct ancient sediment dispersal patterns. By measuring structures like cross-bedding or flute casts, they can determine the direction from which sediment was transported into a basin. This information is vital for understanding ancient paleogeography, identifying source areas, and mapping the distribution of different sedimentary facies across a geological basin.

270. (A) Both A and R are true and R is the correct explanation of A.
Greywackes are sandstones that are considered both texturally and compositionally immature. This is because they contain a high proportion of fine-grained clay matrix and a significant amount of unstable minerals and rock fragments. These features indicate that the sediment underwent minimal transport and weathering, typical of rapid deposition in tectonically active areas like deep marine fans or trenches.

271. (C) P-2, Q-1, R-3, S-4
Different environments produce distinct sediment types. Beaches are characterized by well-sorted sand. Deep marine abyssal plains contain very fine-grained muds and pelagic oozes. Alluvial fans are dominated by poorly sorted breccias and conglomerates. Lagoons often feature laminated muds and sometimes evaporites. Matching these environments with their characteristic deposits is a fundamental skill in facies analysis and environmental reconstruction.

272. (B) Convert unconsolidated sediment into solid rock.
The term 'lithification' specifically refers to the collection of physical and chemical processes that convert loose, unconsolidated sediment into solid sedimentary rock. This typically occurs after the sediment has been buried and involves compaction, which reduces pore space, and cementation, where minerals precipitate from groundwater to bind the grains. Lithification is the final stage in the formation of rock.

255. (B) Both Statement I and Statement II are incorrect.
Heavy minerals are defined by having a high specific gravity, typically greater than 2.85. Their separation and analysis are extremely useful for provenance studies, as different mineral suites can be linked to specific source rock types. Therefore, both statements provided are incorrect regarding the physical properties and the geological utility of heavy minerals in the study of sedimentary rock origins.

256. (B) A volcanic ash layer
Volcanoclastic sediments are those derived from volcanic activity. A volcanic ash layer is a primary example, consisting of fine particles of glass and crystals ejected during an eruption. Unlike common river gravels or beach sands, which are produced by the erosion of continental rocks, or rock salt from evaporation, ash layers provide a direct and specific record of ancient volcanic events.

257. (B) Provenance
The term 'provenance' in sedimentology refers specifically to the source area from which a sediment was derived. This includes the geographic location and the parent rock types that were weathered and eroded. Provenance analysis is a key part of basin studies, helping geologists reconstruct ancient paleogeography and understand the tectonic evolution of a region's crust over geological time.

258. (A) Ripple Mark
Ripple marks are primary sedimentary structures that form through the action of currents or waves moving over a loose sediment bed. They are characteristic of many depositional environments, including rivers, beaches, and deserts. In contrast, concretions and stylolites are secondary structures formed during diagenesis, and joints are fractures that develop due to tectonic stress or cooling after rock formation.

259. (C) Clastic rocks are made of fragments, while chemical rocks are made of precipitated minerals.
The main difference between chemical and clastic sedimentary rocks is their origin. Clastic rocks are composed of fragments of pre-existing rocks that have been physically transported and deposited. Chemical rocks form through the precipitation of minerals directly from a water solution, such as the formation of evaporites or certain limestones. This fundamental distinction is used in all sedimentary classification systems.

260. (D) 1, 2 and 3
Texture provides vital clues about a sediment's history. Well-sorted sediments indicate a consistent energy level. Angular grains suggest minimal transport and proximity to the source area. Textural maturity, which involves both sorting and roundness, increases as sediment is transported further from its origin. All three statements accurately describe how texture reflects the transport and depositional processes in various sedimentary environments.

261. (C) Water, air, or ice that transports sediment.
In the context of sedimentation, 'fluid flow' refers to the movement of water, air, or ice. These are the primary agents of transport that carry sediment from its source to the site of deposition. The dynamics of this flow, such as its velocity and whether it is laminar or turbulent, directly control the size of the particles that can be moved.

262. (B) It is composed of gravel-sized (>2mm) particles.
A 'rudite' is a coarse-grained clastic sedimentary rock. Its defining characteristic is that the dominant grains are in the gravel size range, which means they are larger than two millimeters in diameter. This category includes conglomerate and breccia. Rudites typically form in high-energy environments, such as mountain streams or at the base of cliffs, where large fragments can be deposited.

263. (D) Regression (sea-level fall)
A sequence of rocks transitioning from deep-water shales up into shallow-water sandstones and then into coastal plain coals represents a shallowing-upward trend. This is characteristic of a marine regression, where the sea level falls or sediment supply exceeds subsidence, causing the shoreline to move seaward. This sequence records the progradation of terrestrial and nearshore environments over formerly deeper marine settings.

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246. (B) Metamorphic
Depositional environments are those where sediment accumulates at the Earth's surface. Continental, transitional, and marine are the three major categories of these environments. Metamorphic is not a depositional environment; rather, it refers to a process that changes existing rocks under high heat and pressure, typically deep within the crust, where surface sedimentation and transport processes do not occur.

247. (D) Coquina or Bioclastic limestone
A limestone that is composed predominantly of fossil fragments is known as a bioclastic limestone or coquina. These rocks form from the accumulation of shells and skeletal remains of marine organisms. They are a type of biochemical sedimentary rock. This distinguishes them from oolitic limestones, which are made of inorganic ooids, or micrites, which are primarily made of fine carbonate mud.

248. (A) The roundness of the clasts.
Both conglomerate and breccia are coarse-grained clastic rocks containing gravel-sized clasts. The primary factor that distinguishes them is the roundness of these clasts. Conglomerates have rounded clasts, indicating significant transport and abrasion by water. Breccias consist of angular fragments, which imply very little transport and that the sediment was deposited close to its original source area before undergoing any significant mechanical wear.

249. (C) It ranks minerals by their resistance to chemical weathering at the Earth's surface.
The Goldich stability series is highly significant for provenance analysis because it ranks common minerals based on their resistance to chemical weathering at the Earth's surface. By observing which minerals are present or absent in a sediment, geologists can infer the degree of weathering and transport the material has undergone, as well as the climatic conditions of the source area.

250. (A) Both A and R are true and R is the correct explanation of A.
Dunham's classification system for carbonate rocks is fundamentally based on depositional texture. It focuses on the physical relationship between the framework grains and the mud matrix. Key criteria include whether the rock is mud-supported or grain-supported and the relative amount of mud matrix present. This provides immediate information about the energy levels and environmental conditions during the accumulation of sediment.

251. (D) Arkose
In the classification of sandstones, an Arkose is a rock characterized by a high content of feldspar grains. By standard definition, a sandstone containing more than twenty-five percent feldspar is classified as an arkose. These rocks typically suggest a source area rich in granitic or gneissic rocks and a relatively short transport history where unstable feldspars were not fully weathered away.

252. (B) Particle size
The primary classification of clastic sedimentary rocks is based on particle size. Rocks are categorized into three broad groups: rudites, arenites, and argillites. This classification system is standard in sedimentology because grain size is a direct reflection of the energy of the transport and depositional medium. Correct identification of particle size is essential for environmental interpretation and facies analysis.

253. (C) The physical, chemical, and biological processes operating in the area of deposition.
A depositional environment is defined by the unique combination of physical, chemical, and biological processes that operate in a specific geographic area. These processes, such as wave action, salinity, and the activity of organisms, determine the characteristics of the sediment that accumulates there. Understanding these environments is essential for interpreting the conditions and processes present on the ancient Earth.

254. (D) Inversely or reverse graded bedding
Normal graded bedding shows a decrease in grain size toward the top. Inversely or reverse graded bedding is characterized by a progressive increase in grain size from the bottom to the top of a bed. This less common structure can occur in certain high-concentration flows, such as debris flows, where mechanical interactions push larger particles toward the top during movement.

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273. (A) Both Statement I and Statement II are correct.
The grain size of a clastic sediment is a direct reflection of the energy in the depositional medium. High-energy environments, such as fast-flowing rivers or wave-swept beaches, have the capacity to transport and deposit larger particles. In contrast, low-energy environments like quiet lakes or deep oceans only have enough energy to keep the finest particles in suspension, leading to fine-grained deposits.

274. (A) Chert, siltstone, and low-grade metamorphic fragments.
In a 'recycled orogen' provenance, sediment is derived from the erosion of uplifted mountain belts composed of pre-existing sedimentary and low-grade metamorphic rocks. As a result, the resulting sandstones are typically rich in lithic fragments from these sources, such as chert, siltstone, and low-grade metamorphic rock fragments. These fragments provide clear evidence of the tectonic history of the source area.

275. (C) Evaporite (Chemical)
Halite, or rock salt, is classified as an evaporite. This is a type of chemical sedimentary rock that forms through the precipitation of dissolved ions from water when it evaporates. Halite typically forms in restricted marine basins or saline lakes in arid environments. It is distinct from clastic rocks made of fragments or organic rocks made of biological remains in the sequence.

276. (D) The orientation and packing of the constituent grains.
In a sedimentary rock, 'fabric' refers to the orientation and packing of the constituent grains. It describes how the grains are arranged in space, including any preferred alignment caused by currents or the way they are packed together during deposition and compaction. Fabric is a key textural element that provides information about the depositional processes and post-depositional changes.

277. (C) The relative abundance of quartz, feldspar, and rock fragments
The standard classification of sandstones is based on the relative abundance of three main framework grains: quartz, feldspar, and lithic fragments. By determining the proportions of these three components, geologists can categorize sandstones into types like quartz arenite, arkose, and litharenite. This mineralogical classification is essential for interpreting the provenance and tectonic setting of the source area from which they originated.

278. (B) Asthenospheric mantle
Provenance analysis classifies source areas by their tectonic setting. Standard types include magmatic arcs, continental blocks, and recycled orogens. Each setting produces sandstones with a distinct mineralogical signature. The asthenospheric mantle is a layer of the Earth's interior and is not a surface source area that directly provides sediment to basins, making it an incorrect type of provenance in this context.

279. (D) The replacement of pre-existing calcite or aragonite.
The formation of dolomite in most ancient geological sequences is believed to occur through the diagenetic replacement of pre-existing carbonate minerals like calcite or aragonite. This process, known as dolomitization, typically involves the circulation of magnesium-rich fluids through limestone. While primary precipitation can occur in some rare modern environments, it is not the dominant mechanism for forming large dolostone bodies.

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280. (A) The migration of ripples or dunes.
Cross-bedding is a common primary sedimentary structure formed by the migration of bedforms like ripples or dunes in a current. As sediment is moved by wind or water, it is deposited on the sheltered lee side of the bedform in inclined layers. These inclined layers are preserved as cross-beds, which are useful for identifying ancient environments and current direction.

281. (C) The chemical precipitation of minerals into pore spaces, binding sediments together.
Cementation is a key process in diagenesis where minerals precipitate from groundwater into the pore spaces between sediment grains. These minerals, such as calcite, silica, or iron oxides, act as a natural glue that binds the grains together. This process is essential for the lithification of loose sediment into solid rock and is one of the primary ways that porosity is reduced.

surface. These parent rocks can be igneous, metamorphic, or older sedimentary rocks. The physical and chemical breakdown of these materials produces the fragments that are then transported and deposited to form new sedimentary layers in the cycle.

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291. (C) Sand-sized grains
In the classification of clastic rocks, an 'arenite' is a rock where the primary framework components are sand-sized grains. In sandstones, this also specifically implies a rock with a very low percentage of fine-grained matrix. Arenites are distinct from rudites, which are gravel-rich, and argillites, which are composed of the finest silt and clay particles in the classification system.

292. (D) Fragmental material ejected from a volcano.
Volcanoclastic sediment is composed of fragmental material that was produced by volcanic activity. This includes volcanic ash, crystals, and rock fragments that were ejected during explosive eruptions or redistributed by surface processes. These sediments provide important evidence of ancient volcanic history and are distinct from sediments formed by general weathering or the accumulation of organic remains in other environments.

293. (A) Both Statement I and Statement II are correct.
In sedimentary petrology, texture and structure are two distinct concepts. Texture refers to the small-scale properties of individual grains, such as their size, sorting, and roundness. Structure refers to the larger-scale features of the rock body, such as bedding, cross-bedding, and ripple marks. Both statements correctly define these terms, which are fundamental for describing and interpreting sedimentary rocks in the field.

294. (B) Quartz
The mineral stability series describes how resistant minerals are to chemical weathering at the Earth's surface. Quartz is exceptionally stable because it is chemically inert and physically hard. Unlike minerals like olivine or pyroxene, which weather rapidly into clay, quartz can survive long transport distances and multiple cycles of erosion and redeposition. This makes it the most common mineral in mature sediments.

295. (D) Mudstone or Wackestone
In Dunham's classification of carbonate rocks, rocks are categorized by whether they are mud-supported or grain-supported. A limestone where the grains are not in contact and are supported by a muddy matrix is mud-supported. Such a rock is classified as either a mudstone, if it has less than ten percent grains, or a wackestone, if it has more than ten percent.

296. (A) Rivers and streams
A fluvial system is a depositional environment that is dominated by the action of rivers and streams. This includes the transport and deposition of sediment in river channels, on floodplains, and in associated features like point bars and oxbow lakes. Fluvial sediments are characterized by structures like cross-bedding and often show a downstream decrease in grain size and an increase in roundness.

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297. (A) P-3, Q-4, R-1, S-2
Different specialized fields in sedimentology focus on specific aspects of rocks. Granulometry is the analysis of grain size distribution. Palaeocurrent analysis determines ancient flow directions using structures. Provenance analysis aims to reconstruct the original source rocks. Diagenesis study investigates the post-depositional changes that turn sediment into rock. Matching these fields correctly is essential for understanding the comprehensive study of sedimentary systems.

298. (A) Abrasion
Abrasion is the physical process that occurs during sediment transport as grains collide with each other and with the bed. This mechanical wear causes the grains to become increasingly rounded as their sharp edges are smoothed away. Abrasion also contributes to the reduction in particle size over long transport distances. This process is a key factor in the physical maturation of clastic sediments.

299. (D) Concretion
Primary sedimentary structures like bedding planes, cross-stratification, and ripple marks form during the process of deposition. A concretion, however, is a secondary structure. It forms during diagenesis as minerals precipitate from pore fluids around a nucleus after the sediment has already been deposited and buried. Concretions are often harder and more resistant than the surrounding rock matrix in the stratigraphic sequence.

300. (B) The weathering of pre-existing rocks
The ultimate origin of the material that forms clastic sedimentary rocks is the weathering and erosion of pre-existing rocks on the Earth's

(A) P-3, Q-1, R-2, S-4
(B) P-4, Q-2, R-1, S-3
(C) P-3, Q-1, R-4, S-2
(D) P-1, Q-3, R-2, S-4

9. All of the following are major tectonic divisions of India EXCEPT:
(A) The Peninsular Shield
(B) The Extra-Peninsular Himalayan Region
(C) The Andaman-Nicobar Volcanic Arc
(D) The Indo-Gangetic Plains

10. Consider the following statements regarding stratigraphic units:
1. A 'Formation' is the fundamental unit of lithostratigraphy.
2. A 'System' is the chronostratigraphic equivalent of a geochronologic 'Period'.
3. An 'Assemblage Zone' is a type of lithostratigraphic unit.

Which of the above statement(s) is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

11. The Archaean rocks of the Singhbhum region in Jharkhand are economically important primarily for their deposits of:
(A) Limestone and Dolomite
(B) Coal and Petroleum
(C) Bauxite and Manganese
(D) Copper, Uranium, and Iron

12. The term 'Azoic' as applied to the Archaean history of India implies:
(A) An abundance of well-preserved fossils
(B) The absence of definitive life forms
(C) A period dominated by volcanic activity
(D) The prevalence of a reducing atmosphere

13. The Dharwar Supergroup, a classic example of Archaean rocks in South India, is well-known for its:
(A) Extensive coal seams
(B) Diamondiferous kimberlite pipes
(C) Rich gold deposits in the Kolar region
(D) Large reserves of rock salt

14. Which of the following identifies a correct pair of Archaean rock group and its location?
(A) Iron Ore Group - Rajasthan
(B) Banded Gneissic Complex - South India
(C) Champion Gneiss - Jharkhand
(D) Khondalite Group - Orissa (Eastern Ghats)

15. The Precambrian rocks in India are broadly divided into:
(A) The Archaean and the Proterozoic
(B) The Dharwar and the Vindhyan
(C) The Cuddapah and the Gondwana
(D) The Siwalik and the Deccan Traps

16. Arrange the following eons of the Geological Time Scale in chronological order from oldest to youngest:
1. Proterozoic
2. Archaean
3. Phanerozoic
4. Hadean

Which of the following is the correct sequence?
(A) 2, 4, 1, 3
(B) 4, 2, 1, 3
(C) 1, 2, 4, 3
(D) 4, 1, 2, 3

17. The Cuddapah Supergroup is an important Proterozoic sedimentary basin located primarily in:
(A) Rajasthan
(B) Andhra Pradesh
(C) Jharkhand
(D) Madhya Pradesh

18. Evaluate the following statements regarding the Cuddapah and Vindhyan Supergroups:
Statement I : The Cuddapah basin is characterized by its crescent shape and contains a thick sequence of unmetamorphosed sedimentary rocks.
Statement II : The Vindhyan Supergroup is younger than the Cuddapah Supergroup.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

19. The Vindhyan Supergroup is of great economic importance due to its extensive deposits of:
(A) Iron ore, manganese, and chromite
(B) Coal, lignite, and petroleum
(C) Building stones, cement-grade limestone,

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CHAPTER 06

Indian stratigraphy and Palaeobiology

1. What is the fundamental mapping unit in lithostratigraphy?
(A) Supergroup
(B) Formation
(C) Group
(D) Member

2. Evaluate the following statements regarding bio-stratigraphic units:
Statement I : Bio-stratigraphic units are bodies of rock strata defined by their fossil content.
Statement II : A biozone is independent of lithological boundaries and can cross them.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

3. Which of the following represents a geochronologic unit?
(A) System
(B) Series
(C) Period
(D) Stage

4. A geologist observes a succession of sedimentary layers where a marine transgression is followed by a regression. This entire package of related strata bounded by unconformities is best studied under which branch of stratigraphy?
(A) Lithostratigraphy
(B) Biostratigraphy
(C) Magneto-stratigraphy
(D) Sequence stratigraphy

5. Which of the following is an incorrect statement about chronostratigraphic units?
(A) They are bodies of rock established to serve as the material reference for all rocks formed during the same span of time.
(B) An Eonothem represents the highest rank within the standard hierarchy of chronostratigraphic units.
(C) Chronostratigraphic units are defined primarily on the basis of their inherent fossil content.
(D) The boundaries of chronostratigraphic units are considered to be always globally synchronous.

6. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option:
Assertion (A) : Correlation in stratigraphy aims to establish the equivalence of rock units in different areas.
Reason (R) : The presence of identical index fossils in two geographically separate rock units suggests they were deposited during the same time interval.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

7. The study of the remnant magnetic properties of rocks to establish a chronological framework is known as:
(A) Seismo-stratigraphy
(B) Chemo-stratigraphy
(C) Cyclo-stratigraphy
(D) Magneto-stratigraphy

8. Match the items in List I with those in List II and select the correct option:
List I: (Stratigraphic Unit)
P. Group
Q. Biozone
R. Period
S. System
List II: (Type of Unit)
1. Biostratigraphic Unit
2. Geochronologic Unit
3. Lithostratigraphic Unit
4. Chronostratigraphic Unit

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282. (A) A quiet, anoxic, deep-water basin.
The preservation of delicate fossils requires specific environmental conditions. A quiet, low-energy, and often anoxic deep-water basin is ideal. In these settings, fine-grained sediment can slowly bury the remains, protecting them from scavenging, mechanical damage from waves, and rapid decay. High-energy environments like beaches or fast rivers are much more likely to destroy delicate organic remains.

283. (D) Bowen's reaction series
The chemical stability of common minerals at the Earth's surface follows a specific order, known as the Goldich stability series. This series is generally the inverse of Bowen's reaction series. Minerals that crystallize at the highest temperatures, such as olivine, are the least stable at surface conditions. Conversely, minerals like quartz that form at lower temperatures are much more resistant to weathering.

284. (B) 2 and 3 only
Granulometric analysis is a fundamental technique in clastic sedimentology. It involves measuring the distribution of grain sizes in a sample. From this data, several statistical parameters are derived, including the mean grain size and sorting. While it describes the physical texture, it is not primarily used to determine mineral composition. Therefore, only statements two and three are correct in this context.

285. (C) Micrite
In Folk's classification of limestones, a rock that is composed almost entirely of fine-grained carbonate mud is called a micrite. This microcrystalline calcite matrix reflects deposition in a low-energy environment where fine particles could settle out of suspension. Micrite is a common component of many limestones, often forming the matrix that supports other grains like bioclasts or ooids in a sample.

286. (D) It lies at the boundary between continental and marine environments.
The defining characteristic of a transitional depositional environment is its location. Transitional environments lie exactly at the boundary between continental and marine settings. Prime examples include deltas, beaches, and lagoons. These areas are influenced by both terrestrial processes, such as river input, and marine processes, such as tides and waves, creating a unique set of sedimentary characteristics in the resulting rock.

287. (A) Sandstone
A sandstone is a classic example of a clastic sedimentary rock. It is specifically defined as being composed predominantly of sand-sized grains, which range from one-sixteenth of a millimeter to two millimeters in diameter. Sandstones are one of the most common sedimentary rocks on Earth and form in a variety of environments, including river beds, beaches, and desert dunes during sediment accumulation.

288. (A) Both A and R are true and R is the correct explanation of A.
Sedimentary structures are essential tools for geologists because they provide direct evidence for interpreting ancient depositional environments. Different structures form under very specific physical or biological conditions. For example, mud cracks reliably indicate subaerial exposure and desiccation. By studying these features, geologists can reconstruct the history of the Earth's surface and the processes that shaped ancient landscapes over time.

289. (B) Sand
In the standard Wentworth scale used in sedimentology, particles are classified by their diameter. Sand is the term used for sediment grains with a size between one-sixteenth of a millimeter and two millimeters. Grains smaller than this are silt and clay, while those larger than two millimeters are classified as gravel. This standardized terminology is crucial for consistent rock and sediment description worldwide.

290. (A) II, I, IV, III
According to the Wentworth scale, clastic particles are classified by diameter. Arranging them from the largest to the smallest, a pebble is a coarse gravel-sized particle. Sand follows, being smaller than gravel. Silt is finer than sand, and clay is the finest fraction of all. Therefore, the correct descending sequence of size is pebble, sand, silt, and finally clay.

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and diamonds
(D) Gold, silver, and copper

20. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option:
Assertion (A) : The Vindhyan sequence is largely devoid of convincing megafossils.
Reason (R) : The Vindhyan sediments were deposited during the Proterozoic Eon, before the Cambrian explosion of life.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

21. The famous Panna diamond mines are associated with which geological formation?
(A) Cuddapah Supergroup
(B) Dharwar Supergroup
(C) Vindhyan Supergroup
(D) Gondwana Supergroup

22. The Palaeozoic succession in the Salt Range, Pakistan, is famous for its early Cambrian fossils, especially:
(A) Graptolites
(B) Trilobites and Brachiopods
(C) Dinosaurs
(D) Foraminifera

23. The 'Saline Formation' or Punjab Saline Series in the Salt Range is controversial regarding its age. What are the two primary proposed ages?
(A) Archaean and Proterozoic
(B) Jurassic and Cretaceous
(C) Permian and Triassic
(D) Cambrian and Eocene

24. Consider the following statements regarding the Proterozoic history of India:
1. The Cuddapah Supergroup is divided into four groups: Papaghni, Chitravati, Nallamalai, and Srisailam.
2. The Vindhyan Supergroup is known for its stromatolite-bearing limestones.
3. Asbestos and Barytes are economically extracted from the Cuddapah rocks.

Which of the above statement(s) is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

25. The Palaeozoic sequence exposed in the Spiti valley of the Himalayas is known for its:
(A) Thick deposits of terrestrial coal-bearing strata
(B) Extensive volcanic lava flows similar to the Deccan Traps
(C) Complete and highly fossiliferous marine succession from Cambrian to Permian
(D) Unfossiliferous and highly metamorphosed rocks

26. The Mesozoic history of the Spiti region is exceptionally well-represented by the fossiliferous marine sediments of which period?
(A) Triassic
(B) Jurassic
(C) Cretaceous
(D) Permian

27. Match the items in List I with those in List II and select the correct option:
List I: (Geological Supergroup/Group)
P. Dharwar Supergroup
Q. Vindhyan Supergroup
R. Gondwana Supergroup
S. Cuddapah Supergroup
List II: (Primary Economic Importance)
1. Coal
2. Building Stone (Sandstone)
3. Iron and Gold
4. Barytes and Asbestos
(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-2, R-1, S-4
(C) P-3, Q-4, R-1, S-2
(D) P-1, Q-3, R-4, S-2

28. The Jurassic rocks of Kutch (Kachchh) are renowned for their rich fossil fauna, particularly:
(A) Graptolites
(B) Ammonites
(C) Trilobites
(D) Dinosaurs

29. The Cretaceous rocks of South India, especially the Tiruchirappalli (Trichinopoly) area, are famous for:

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mesoskeleton
(D) A glabella, genal spine, and fixigena

50. Evaluate the following statements regarding trilobites:
Statement I : Trilobites are an extinct group of marine arthropods.
Statement II : Trilobites serve as excellent index fossils for the Mesozoic Era.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

51. The colonial, planktonic organisms known as graptolites are particularly useful as index fossils for which two geological periods?
(A) Cambrian and Precambrian
(B) Jurassic and Cretaceous
(C) Ordovician and Silurian
(D) Tertiary and Quaternary

52. Thecal arrangement and the number of stipes (branches) are key morphological features used in the classification of:
(A) Echinoids
(B) Corals
(C) Trilobites
(D) Graptolites

53. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option:
Assertion (A) : Fossils are primarily found in sedimentary rocks.
Reason (R) : The high temperature and pressure conditions associated with the formation of igneous and metamorphic rocks typically destroy any organic remains.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

54. The 'test' of an echinoid is composed of plates showing pentameral (five-fold) symmetry. This test is made of:
(A) Chitin
(B) Calcite (Calcium Carbonate)
(C) Silica
(D) Phosphate

55. The ambulacral and interambulacral areas are characteristic morphological features of:
(A) Brachiopods
(B) Cephalopods
(C) Gastropods
(D) Echinoids

56. Corals, belonging to the phylum Cnidaria, are primarily known for their ability to:
(A) Build massive reefs from their calcium carbonate skeletons
(B) Swim actively in the water column
(C) Burrow deep into marine sediments
(D) Filter feed using a lophophore

57. The Rugosa and Tabulata are two major extinct orders of:
(A) Brachiopods
(B) Echinoids
(C) Corals
(D) Graptolites

58. Consider the following statements regarding invertebrate fossils:
1. Trilobites possessed a calcite exoskeleton and compound eyes.
2. Graptolites were colonial organisms, and their fossils often look like pencil markings on rock.
3. Echinoids are exclusively Palaeozoic fossils.
Which of the above statement(s) is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

59. What is the primary distinguishing feature between a brachiopod shell and a lamellibranch (bivalve) shell?
(A) Brachiopods have a chitinous shell, while lamellibranchs have a calcareous shell.
(B) Brachiopods are always coiled, while lamellibranchs are never coiled.
(C) Brachiopods are found only in marine environments, while lamellibranchs are found only in freshwater.
(D) Brachiopods are equilateral and inequivalved, while lamellibranchs are

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1. The Triassic of Spiti contains well-preserved ammonites like Ceratites.
2. The Jurassic of Kutch is divided into Patcham, Chari, Katrol, and Umia series.
3. The Bagh Beds of the Narmada valley are of Jurassic age.

Which of the above statement(s) is/are correct?
(A) 1 and 3 only
(B) 2 only
(C) 1 and 2 only
(D) 1, 2 and 3

41. The Siwalik Group represents:
(A) Deep marine sediments deposited during the Cretaceous
(B) Ancient metamorphic rocks of the Peninsular Shield
(C) Fluvial (river-deposited) sediments shed from the rising Himalayas
(D) Volcanic ash beds associated with the Deccan Traps

42. The Siwalik Group is world-renowned for its exceptionally rich fossil record of:
(A) Tertiary mammals, including primates and elephants
(B) Marine invertebrates
(C) Early Palaeozoic trilobites
(D) Flying reptiles (Pterosaurs)

43. The K-T Boundary problem primarily deals with the:
(A) Transition from Cambrian to Ordovician life
(B) Origin of life during the Archaean
(C) Boundary between the Cuddapah and Vindhyan Supergroups
(D) Mass extinction event at the end of the Cretaceous period

44. Which process of fossilization involves the infilling of pores and cavities in a bone or shell by mineral-rich groundwater?
(A) Carbonization
(B) Permineralization (Petrifaction)
(C) Replacement
(D) Casting

45. Arrange the following Indian stratigraphic units in chronological order from oldest to youngest:
1. Siwalik Group
2. Vindhyan Supergroup
3. Gondwana Supergroup
4. Dharwar Supergroup

Which of the following is the correct sequence?
(A) 4, 2, 3, 1
(B) 2, 4, 3, 1
(C) 4, 3, 2, 1
(D) 2, 3, 4, 1

46. The preservation of an organism as a thin film of carbon, common for leaves and graptolites, is called:
(A) Moulding
(B) Casting
(C) Amber entombment
(D) Carbonization

47. All of the following are significant uses of fossils EXCEPT:
(A) Determining the absolute age of igneous rocks
(B) Correlating rock strata from different locations
(C) Reconstructing ancient environments (palaeoecology)
(D) Providing evidence for the theory of evolution

48. Match the items in List I with those in List II and select the correct option:
List I: (Fossil Group)
P. Trilobites
Q. Graptolites
R. Ammonites
S. Nummulites
List II: (Typical Geological Age)
1. Mesozoic
2. Eocene (Tertiary)
3. Palaeozoic
4. Ordovician-Silurian
(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-4, R-1, S-2
(C) P-3, Q-1, R-4, S-2
(D) P-4, Q-3, R-2, S-1

49. The three-lobed body of a trilobite is divided longitudinally into:
(A) Cephalon, thorax, and pygidium
(B) A central axial lobe and two lateral pleural lobes
(C) An exoskeleton, endoskeleton, and

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(A) The first discovery of hominid fossils in India
(B) Extensive coal deposits
(C) A rich assemblage of marine invertebrate fossils
(D) Well-preserved Gondwana flora

30. The 'Bagh Beds' are a series of marine fossiliferous rocks of Cretaceous age found in the:
(A) Godavari Valley
(B) Spiti Valley
(C) Cauvery Basin
(D) Narmada Valley

31. Which of the following statements about the Lameta Beds is incorrect?
(A) They are a thick sequence of marine shales.
(B) They are of Late Cretaceous age.
(C) They are famous for dinosaur skeletal remains and eggs.
(D) They often underlie the Deccan Traps.

32. The Deccan Traps are a classic example of:
(A) A folded mountain belt formed by continental collision
(B) A large igneous province formed by fissure-type volcanic eruptions
(C) A sedimentary basin filled with marine sediments
(D) A metamorphic terrain with high-grade gneisses

33. Identify the stratigraphic unit based on the following geological observation:
A geological survey team is exploring a region with alternating layers of sandstone, shale, and coal seams. The fossil flora includes Glossopteris, Gangamopteris, and Vertebraria.
(A) Vindhyan Supergroup
(B) Gondwana Supergroup
(C) Cuddapah Supergroup
(D) Siwalik Group

34. The term 'Gondwana' was named after the ancient kingdom of the Gonds in which part of India?
(A) Central India (Madhya Pradesh/Andhra Pradesh)
(B) Rajasthan
(C) Assam
(D) Tamil Nadu

35. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option:
Assertion (A) : The Gondwana Supergroup sediments were deposited in a series of fault-bounded troughs or basins.
Reason (R) : The deposition of Gondwana sediments was initiated by tensional tectonics related to the rifting of the Gondwanaland supercontinent.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

36. The primary economic importance of the Gondwana Supergroup in India is its vast reserves of:
(A) Iron ore
(B) Petroleum
(C) Limestone
(D) Coal

37. The palaeoclimate during the deposition of the Lower Gondwana (Talchir Formation) is inferred to be:
(A) Hot and arid
(B) Tropical and humid
(C) Cold and glacial
(D) Temperate and marine

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38. Which of the following is NOT a characteristic feature of the Gondwana flora?
(A) Presence of Glossopteris
(B) Presence of Angiosperms
(C) Presence of Gangamopteris
(D) Presence of Vertebraria

39. The Tertiary succession in Assam is economically significant due to the presence of:
(A) Gold and diamonds
(B) Iron and manganese
(C) Copper and uranium
(D) Coal and petroleum

40. Consider the following statements regarding Mesozoic formations in India:

equivalved and inequilateral.

60. The lophophore is a complex, coiled, filter-feeding organ found in:
(A) Cephalopods
(B) Brachiopods
(C) Gastropods
(D) Lamellibranchs

61. The process by which the original hard parts of a fossil are dissolved and replaced, molecule by molecule, with a different mineral is called:
(A) Permineralization
(B) Carbonization
(C) Replacement
(D) Distillation

62. Which of the following is an example of a trace fossil?
(A) A dinosaur bone
(B) A petrified tree trunk
(C) A trilobite exoskeleton
(D) A fossilized worm burrow

63. The single, uncoiled, cap-shaped shell is a defining characteristic of some primitive members of which class?
(A) Gastropoda
(B) Cephalopoda
(C) Lamellibranchia
(D) Brachiopoda

64. 'Torsion' is a unique evolutionary event in the development of which group, resulting in the twisting of the visceral mass?
(A) Lamellibranchia
(B) Gastropoda
(C) Cephalopoda
(D) Brachiopoda

65. The shells of Lamellibranchia (bivalves) are held together at the dorsal margin by:
(A) A complex suture line
(B) An elastic ligament and interlocking hinge teeth
(C) A pedicle opening
(D) Septa and a siphuncle

66. Which morphological feature is characteristic of the Cephalopoda and distinguishes them from other molluscs?
(A) The presence of internal chambers connected by a siphuncle.
(B) The presence of a two-valved shell with equilateral symmetry.
(C) The presence of a lophophore used exclusively for filter feeding.
(D) The unique process of torsion during the larval stage of development.

67. Ammonoids, an extinct group of cephalopods, are known for their increasingly complex suture lines through time. What is the general evolutionary trend of suture patterns from the Palaeozoic to the Mesozoic?
(A) Ammonitic → Ceratitic → Goniatitic
(B) Goniatitic → Ceratitic → Ammonitic
(C) Ceratitic → Ammonitic → Goniatitic
(D) Goniatitic → Ammonitic → Ceratitic

68. Arrange the first appearance of the following vertebrate groups in the fossil record in chronological order, from earliest to latest:
1. Mammals
2. Amphibians
3. Reptiles
4. Fish

Which of the following is the correct sequence?
(A) 4, 2, 3, 1
(B) 2, 4, 3, 1
(C) 4, 3, 2, 1
(D) 1, 2, 3, 4

69. The Mesozoic Era is often referred to as the Age of":
(A) Mammals
(B) Invertebrates
(C) Reptiles
(D) Fishes

70. The succession of vertebrate life shows that birds are most closely related to and evolved from:
(A) Pterosaurs (flying reptiles)
(B) Theropod dinosaurs
(C) Early amphibians
(D) Synapsid reptiles

71. Micropaleontology is the study of fossils that require a microscope for observation. It is particularly useful in fossil fuel exploration because:
(A) Microfossils directly indicate the presence

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92. The classification of the Archaean rocks of South India includes the 'Sargur Group' and the 'Dharwar Supergroup'. What is the generally accepted age relationship between them?
(A) Sargur Group is younger than the Dharwar Supergroup.
(B) Sargur Group is older than the Dharwar Supergroup.
(C) They are of the same age but deposited in different basins.
(D) The Sargur Group is a subdivision of the Dharwar Supergroup.

93. Identify the stratigraphic unit based on the following geological observation:
A geologist is examining a sequence of rocks containing stromatolites, red sandstones, and limestones that are largely undeformed.
(A) Dharwar Supergroup
(B) Gondwana Supergroup
(C) Vindhyan Supergroup
(D) Siwalik Group

94. The Mesozoic succession in Kutch is particularly famous for its rich ammonite fauna. The presence of these fossils indicates that the depositional environment was:
(A) Fluvial
(B) Glacial
(C) Aeolian
(D) Marine

95. Evaluate the following statements regarding the Deccan Traps and Lameta Beds:
Statement I : The Deccan Traps covered a vast area of peninsular India during the Late Cretaceous to Early Tertiary.
Statement II : The Lameta Beds, containing dinosaur fossils, are often found directly underlying the Deccan Traps.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

96. The two major subdivisions of the Gondwana Supergroup are:
(A) Marine and Terrestrial Gondwana
(B) Lower and Upper Gondwana
(C) Peninsular and Extra-Peninsular Gondwana
(D) Eastern and Western Gondwana

97. Consider the following statements regarding Indian stratigraphy:
1. The oil fields of Assam (e.g., Digboi) produce from Tertiary sandstones.
2. The Siwalik sediments are largely marine in origin.
3. The K-T boundary marks the end of the Mesozoic Era.

Which of the above statement(s) is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

98. The morphology of a brachiopod shell includes a 'pedicle opening'. What is the function of this feature?
(A) To extrude a fleshy stalk for attachment to the substrate.
(B) To allow water to enter for filter feeding.
(C) To serve as an opening for the siphuncle.
(D) To allow the protoconch to emerge during growth.

99. Which of the following invertebrate groups survived the end-Permian mass extinction but became extinct at the end of the Cretaceous?
(A) Trilobites
(B) Graptolites
(C) Ammonites
(D) Rugose Corals

100. In micropaleontology, what is the primary application of the planktonic/benthic foraminifera ratio (P/B ratio)?
(A) To determine the palaeosalinity of the water
(B) To measure the rate of sediment accumulation
(C) To identify the absolute age of the rock
(D) To estimate the palaeodepth of the depositional environment

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101. The transition from spore-bearing plants (like ferns) to seed-bearing plants (gymnosperms) was a major evolutionary step because:
(A) Seeds were much larger and could store more food.
(B) Seed-bearing plants were the first to have leaves.
(C) Seeds allowed plants to reproduce without dependence on water.

(D) Epoch

82. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option:
Assertion (A) : The Archaean rocks of India are generally unfossiliferous.
Reason (R) : Most Archaean rocks are highly metamorphosed and deformed, which would have destroyed any potential fossil evidence.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

83. The Banded Gneissic Complex is a major Archaean terrain characteristic of which Indian state?
(A) Jharkhand
(B) Karnataka
(C) Rajasthan
(D) Orissa

84. The 'Papaghni Group' and 'Chitravati Group' are stratigraphic subdivisions of the:
(A) Vindhyan Supergroup
(B) Cuddapah Supergroup
(C) Dharwar Supergroup
(D) Gondwana Supergroup

85. Which of the following is an incorrect pair of Indian geological formation and its predominant rock type?
(A) Deccan Traps - Basalt
(B) Vindhyan Supergroup - Sandstone and Limestone
(C) Siwalik Group - Marine Shale
(D) Dharwar Supergroup - Schist and Gneiss

86. The famous fossiliferous beds of the Spiti valley, such as the 'Lilang Group' and 'Spiti Shales', belong to which geological era?
(A) Palaeozoic
(B) Mesozoic
(C) Cenozoic
(D) Proterozoic

87. Match the items in List I with those in List II and select the correct option:
List I: (Indian Formation)
P. Siwalik Group
Q. Bagh Beds
R. Cuddapah Supergroup
S. Talchir Formation
List II: (Geological Age)
1. Proterozoic
2. Mio-Pliocene
3. Early Permian
4. Cretaceous
(A) P-2, Q-4, R-1, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-1, R-4, S-3
(D) P-4, Q-3, R-2, S-1

88. The presence of a tillite (boulder bed of glacial origin) at the base of the Gondwana Supergroup in the Talchir Formation is strong evidence for:
(A) A widespread glaciation event
(B) A major volcanic eruption
(C) A meteorite impact
(D) A hot desert environment

89. A paleontologist discovers a large assemblage of vertebrate fossils including Stegodon, Sivatherium, and Ramapithecus. These fossils are characteristic of which Indian geological unit?
(A) Lameta Beds
(B) Bagh Beds
(C) Siwalik Group
(D) Spiti Shales

90. The Iridium anomaly at the K-T boundary is considered strong evidence for:
(A) A major bolide (asteroid/comet) impact
(B) A gradual change in climate
(C) A period of intense global volcanism
(D) A reversal of Earth's magnetic field

91. Which of the following is the most appropriate definition of a 'Biozone'?
(A) A body of rock defined by its observable lithological characteristics.
(B) A body of rock deposited during a specific interval of geologic time.
(C) A body of rock characterized by specific and unique magnetic properties.
(D) A body of rock defined on the basis of its inherent fossil content.

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of oil.
(B) All microfossils are phosphatic and glow under UV light.
(C) Microfossils are only found in reservoir rocks.
(D) Microfossils are recovered intact from drill rock cuttings.

72. Foraminifera are single-celled protists that typically build a multi-chambered test. Based on the wall composition of the test, they can be classified into all the following types EXCEPT:
(A) Siliceous
(B) Agglutinated
(C) Microgranular
(D) Porcelaneous

73. Benthic and planktonic foraminifera are used as indicators of past ocean depths and temperatures. If a rock sample contains a high percentage of planktonic foraminifera, what does it likely indicate about the depositional environment?
(A) A shallow, near-shore lagoon
(B) A freshwater river delta
(C) An open-ocean, deep-water setting
(D) A terrestrial, arid desert

74. The concept of palaeobotany primarily involves the study of:
(A) Fossil plants
(B) Fossil animals
(C) Fossil pollen and spores
(D) Fossil footprints

75. Evaluate the following statements regarding palynology:
Statement I : Palynology is the study of microscopic organic-walled entities called palynomorphs, including pollen and spores.
Statement II : Palynology has no application in petroleum exploration.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

76. The evolution of plant life through geological time shows a broad succession from:
(A) Angiosperms → Gymnosperms → Spore-bearing plants
(B) Spore-bearing plants → Gymnosperms → Angiosperms
(C) Gymnosperms → Angiosperms → Spore-bearing plants
(D) Spore-bearing plants → Angiosperms → Gymnosperms

77. Which of the following plant genera is most characteristic of the Gondwana flora?
(A) Lepidodendron
(B) Calamites
(C) Glossopteris
(D) Sigillaria

78. Consider the following statements about palaeontological concepts:
1. Foraminifera are exclusively Mesozoic microfossils.
2. The succession of vertebrate life shows that amphibians appeared before reptiles.
3. Palynology is a branch of micropaleontology.
Which of the above statement(s) is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

79. The geological history of Foraminifera shows their first appearance in the Cambrian and a major radiation during which era?
(A) Mesozoic and Cenozoic
(B) Palaeozoic
(C) Archaean
(D) Proterozoic

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80. What is the most significant characteristic of the plant life during the Carboniferous period, which led to the formation of vast coal deposits?
(A) Dominance of flowering plants in small bushes
(B) Extensive forests of large, spore-bearing trees like lycopods and horsetails
(C) Proliferation of grasses and herbs
(D) First appearance of cacti and other desert plants

81. A 'System' in chronostratigraphy corresponds to which unit in geochronology?
(A) Era
(B) Period
(C) Eon

(D) Spore-bearing plants could not form large trees.

102. Which of the following is an example of a lithostratigraphic unit?
(A) Eon
(B) Group
(C) Era
(D) Period

103. The term 'Champion Gneiss' and 'Peninsular Gneiss' are associated with the Archaean geology of:
(A) Rajasthan
(B) Singhbhum Craton
(C) Aravalli Mountains
(D) South India (Dharwar Craton)

104. Arrange the following subdivisions of the Cuddapah Supergroup in chronological order from oldest to youngest:
1. Srisailam Quartzite
2. Nallamalai Group
3. Papaghni Group
4. Chitravati Group

Which of the following is the correct sequence?
(A) 3, 4, 2, 1
(B) 1, 2, 3, 4
(C) 3, 2, 4, 1
(D) 4, 3, 1, 2

105. The 'Productus Limestone' is a famous fossil-rich Permian formation found in the:
(A) Spiti Valley
(B) Kutch region
(C) Salt Range
(D) Cauvery Basin

106. A geological cross-section shows a sequence of rocks with normal and reversed magnetic polarity zones. A geologist can use this information for:
(A) Magneto-stratigraphic correlation
(B) Lithostratigraphic correlation
(C) Biostratigraphic zonation
(D) Identifying the rock type

107. The 'Ariyalur Group' and 'Uttatur Group' are well-known Cretaceous formations in:
(A) The Narmada Valley
(B) Kutch
(C) The Spiti Valley
(D) South India (Cauvery Basin)

108. The main difference between the Lower Gondwana and Upper Gondwana flora is:
(A) Lower Gondwana is dominated by Angiosperms, while Upper Gondwana is dominated by Gymnosperms.
(B) Lower Gondwana is dominated by Glossopteris flora, while Upper Gondwana is dominated by Ptillophyllum flora.
(C) Lower Gondwana flora is terrestrial, while Upper Gondwana flora is marine.
(D) Lower Gondwana has no fossils, while Upper Gondwana is rich in fossils.

109. Evaluate the following statements regarding Siwalik fauna:
Statement I : The Siwalik fauna provides a continuous record of vertebrate evolution from the Middle Miocene to the Early Pleistocene.
Statement II : The fossils found in the Siwaliks include ancestors of modern elephants, horses, and primates.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

110. The preservation of an insect perfectly encased in fossilized tree resin is an example of fossilization in:
(A) Tar
(B) Ice
(C) Carbon film
(D) Amber

111. The pygidium is the posterior body part or tail-shield of which fossil group?
(A) Trilobites
(B) Graptolites
(C) Echinoids
(D) Corals

112. Irregular echinoids (e.g., heart urchins) differ from regular echinoids (e.g., sea urchins) in that they typically:
(A) Have perfect five-fold symmetry
(B) Are adapted for a burrowing mode of life and have bilateral symmetry
(C) Lack spines

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(D) Live only in freshwater

113. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option:
Assertion (A) : The suture line in ammonoids is a key feature for their classification and biostratigraphic use.
Reason (R) : The complexity of the suture line in ammonoids generally increased through geological time, allowing for fine-scale temporal zonation.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

114. The 'umbo' and 'pallial line' are morphological features found on the shell of a:
(A) Lamellibranch
(B) Gastropod
(C) Brachiopod
(D) Cephalopod

115. A micropaleontologist analyzing a sample from an oil well finds numerous specimens of Globigerina and Globorotalia. These are examples of:
(A) Benthic foraminifera
(B) Calcareous nannofossils
(C) Planktonic foraminifera
(D) Ostracods

116. Which of the following is NOT one of the major cratons of the Indian Peninsular Shield?
(A) Dharwar Craton
(B) Singhbhum Craton
(C) Bundelkhand Craton
(D) Tibetan Craton

117. The Proterozoic basin of the Cuddapah Supergroup is economically important for all the following resources EXCEPT:
(A) Barytes
(B) Asbestos
(C) Coal
(D) Limestone

118. Match the items in List I with those in List II and select the correct option:
List I: (Tectonic Element)
P. Aravalli Mountain Belt
Q. Singhbhum Craton
R. Cuddapah Basin
S. Deccan Volcanic Province
List II: (General Location)
1. Eastern India
2. Northwestern India
3. Central & Western India
4. Southeastern Peninsular India
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-1, R-4, S-3
(C) P-2, Q-4, R-1, S-3
(D) P-3, Q-1, R-4, S-2

119. The origin of the Saline Formation in the Salt Range is debated, with one theory suggesting it is Cambrian and in-situ, while the other suggests it is Eocene and has been:
(A) Metamorphosed to a high grade
(B) Eroded away completely
(C) Deposited in a freshwater lake
(D) Thrust over the younger rocks

120. Consider the following statements regarding the Deccan Traps:
1. They are primarily composed of andesitic lava.
2. The eruptions are linked to the Reunion Hotspot.
3. The lava flows are inter-bedded with sedimentary layers known as 'inter-trappeans'.
Which of the above statement(s) is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

121. The Barakar and Raniganj formations are the most important coal-bearing horizons within the:
(A) Vindhyan Supergroup
(B) Cuddapah Supergroup
(C) Gondwana Supergroup
(D) Tertiary of Assam

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122. The term 'Scleractinia' refers to the modern group of stony corals that are major reef builders today. They first appeared in the:
(A) Triassic
(B) Cambrian
(C) Ordovician
(D) Eocene

123. Which of the following correctly identifies an incorrect pair?
(A) Trilobite - Arthropoda
(B) Graptolite - Hemichordata
(C) Ammonite - Mollusca
(D) Brachiopod - Echinodermata

124. The evolution from a nautiloid-type suture (simple, curved) to a goniatitic suture (simple zig-zag) is a key development seen in early:
(A) Gastropods
(B) Ammonoids
(C) Lamellibranchs
(D) Foraminifera

125. The Cenozoic Era is commonly known as the Age of:
(A) Reptiles
(B) Fishes
(C) Mammals
(D) Amphibians

126. The study of plant microfossils like spores and pollen for stratigraphic correlation and palaeoenvironmental reconstruction is called:
(A) Palaeobotany
(B) Micropaleontology
(C) Palaeozoology
(D) Palynology

127. Which criteria for stratigraphic classification is based on the physical characteristics of the rock layers, such as color, texture, and composition?
(A) Lithostratigraphic criteria
(B) Biostratigraphic criteria
(C) Chronostratigraphic criteria
(D) Magneto-stratigraphic criteria

128. In sequence stratigraphy, a 'sequence' is defined as a relatively conformable succession of genetically related strata bounded by:
(A) Faults
(B) Unconformities or their correlative conformities
(C) Fossil zones
(D) Magnetic polarity reversals

129. The Iron Ore Group (IOG) of Singhbhum and Orissa is a part of which major geological division of India?
(A) Proterozoic
(B) Archaean
(C) Mesozoic
(D) Cenozoic

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130. Evaluate the following statements regarding the Vindhyan and Cuddapah Supergroups:
Statement I : The Vindhyan Supergroup is younger than the Cuddapah Supergroup.
Statement II : The Cuddapah sediments show a greater degree of deformation and low-grade metamorphism compared to the largely undisturbed Vindhyans.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

131. The Triassic sequence of Spiti is well known for its ammonite fauna, including genera like:
(A) Perisphinctes
(B) Belemnites
(C) Ceratites
(D) Gryphaea

132. The 'Katrol Series' and 'Umia Series' are stratigraphic divisions of the Jurassic system in:
(A) Spiti
(B) Salt Range
(C) Trichinopoly
(D) Kutch (Kachchh)

133. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option:
Assertion (A) : The Gondwana sediments are of great economic value to India.
Reason (R) : Approximately 98% of India's coal reserves are found in the Gondwana rocks.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.

178. What is the most significant fossil group found in the Siwalik Hills?
(A) Cenozoic mammals
(B) Palaeozoic flora
(C) Marine invertebrates
(D) Mesozoic reptiles

179. A fossil formed by the filling of a natural mold with minerals is called a:
(A) Trace fossil
(B) Body fossil
(C) Cast
(D) Carbon film

180. Match the items in List I with those in List II and select the correct option:
List I: (Palaeontological Term)
P. Test
Q. Rhabdosome
R. Suture Line
S. Torsion
List II: (Description)
1. Complete skeleton of a graptolite colony
2. Twisting of visceral mass in gastropods
3. The shell of an echinoid or foraminifer
4. Junction between septa and the inner shell wall in ammonites
(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-1, R-4, S-2
(C) P-3, Q-4, R-1, S-2
(D) P-2, Q-3, R-1, S-4

181. The transition from synapsid reptiles to mammals is a key event that occurred during which geological period?
(A) Devonian
(B) Carboniferous
(C) Permian-Triassic
(D) Cretaceous

182. The study of foraminifera is crucial in petroleum geology for biostratigraphy and also for:
(A) Directly detecting the presence of oil stains on their tests
(B) Indicating palaeoclimatic and palaeoceanographic conditions
(C) Determining the engineering properties of the reservoir rock
(D) Measuring the absolute age in millions of years

183. The flora consisting of Glossopteris, Gangamopteris, and Noeggerathiopsis is collectively known as the:
(A) Siwalik Flora
(B) Deccan Inter-trappean Flora
(C) European Carboniferous Flora
(D) Gondwana Flora

184. The 'Geological Time Scale' is a system of chronological dating that relates geological strata to time. It is primarily based on:
(A) The law of superposition and fossil succession
(B) The rate of sea-floor spreading
(C) The cycle of magnetic reversals
(D) The rate of mountain uplift

185. Evaluate the following statements regarding the Indian peninsula:
Statement I : The Archaean rocks form the basement of the Indian peninsula.
Statement II : The Dharwar Supergroup is an example of Archaean rocks.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

186. Which of the following is known for its deposits of building materials like sandstone, often referred to as 'Vindhyan Sandstone'?
(A) Vindhyan Supergroup
(B) Cuddapah Supergroup
(C) Gondwana Supergroup
(D) Dharwar Supergroup

187. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option:
Assertion (A) : The Salt Range in Pakistan presents a geologically complex and condensed stratigraphic succession.
Reason (R) : It contains rocks from the Precambrian to the Tertiary, often in direct tectonic contact due to major faults and thrusts.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

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145. A geologist studying Palaeozoic stratigraphy in the Himalayas would most likely focus on which region for a complete and fossiliferous section?
(A) Kutch
(B) Spiti
(C) Narmada Valley
(D) Assam

146. Which of the following is NOT a member of the Gondwana flora?
(A) Nummulites
(B) Vertebraria
(C) Glossopteris
(D) Gangamopteris

147. A researcher finds sedimentary rocks in central India containing fossilized nests with spherical eggs, alongside skeletal remains of large sauropods. These findings are characteristic of which formation?
(A) Bagh Beds
(B) Spiti Shale
(C) Lameta Formation
(D) Barakar Formation

148. The Tertiary stratigraphy of Assam is divided into the Jaintia, Barail, Surma, and Tipam groups. The 'Barail Group' is particularly important as a:
(A) Major source and reservoir rock for hydrocarbons
(B) Source of building stones
(C) Diamond-bearing horizon
(D) Major coal-bearing sequence

149. Arrange the following eras of the Phanerozoic Eon in chronological order from oldest to youngest:
1. Cenozoic
2. Mesozoic
3. Palaeozoic
Which of the following is the correct sequence?
(A) 2, 3, 1
(B) 3, 2, 1
(C) 1, 2, 3
(D) 3, 1, 2

150. The colonial graptolites with branched colonies (dendroids) are generally considered more primitive than the unbranched, planktonic graptoloids. The graptoloids are more useful for biostratigraphy because:
(A) They were benthic and stayed in one place.
(B) They were geographically widespread and evolved rapidly.
(C) They had hard, robust skeletons that preserved well.
(D) They are much larger and easier to identify.

151. Which of the following statements correctly describes the symmetry of a brachiopod?
(A) The plane of symmetry passes directly through the center of each individual valve.
(B) The two valves (pedicle and brachial) are identical mirror images of one another.
(C) They possess perfect five-fold radial symmetry across the entire skeletal structure.
(D) The plane of symmetry is perpendicular to the hinge line, dividing the shell in half.

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152. Match the items in List I with those in List II and select the correct option:
List I: (Fossil Feature)
P. Siphuncle
Q. Lophophore
R. Pygidium
S. Ambulacral Area
List II: (Fossil Group)
1. Trilobite
2. Echinoid
3. Brachiopod
4. Cephalopod
(A) P-1, Q-2, R-3, S-4
(B) P-4, Q-3, R-1, S-2
(C) P-4, Q-1, R-3, S-2
(D) P-2, Q-3, R-1, S-4

153. 'Dextral' and 'Sinistral' are terms used to describe the direction of coiling in:
(A) Ammonites
(B) Foraminifera
(C) Gastropods
(D) Graptolites

154. The appearance of angiosperms (flowering plants) was a major event in plant evolution that occurred during the:
(A) Cretaceous Period
(B) Permian Period
(C) Triassic Period
(D) Paleogene Period

200. A fossil showing the original skeletal material, but with pore spaces filled by minerals like calcite or silica, has undergone:
(A) Permineralization.
(B) Replacement.
(C) Carbonization.
(D) Recrystallization.

201. Which of the following is NOT a part of the trilobite cephalon?
(A) Glabella
(B) Free cheek (Librigena)
(C) Pleural lobe
(D) Fixed cheek (Fixigena)

202. Thecal structure, number of stipes, and the form of the rhabdosome are key features for identifying:
(A) Graptolites
(B) Corals
(C) Echinoids
(D) Brachiopods

203. The evolutionary trend from Tabulata and Rugosa corals (Palaeozoic) to Scleractinia corals (Mesozoic-Cenozoic) is marked by a change in:
(A) Skeletal composition from silica to calcite
(B) Habitat from marine to freshwater
(C) Symmetry from bilateral to radial
(D) Skeletal mineralogy from calcite to aragonite

204. What is the key morphological feature that distinguishes Cephalopods from all other Molluscs?
(A) Torsion
(B) A chambered shell with a siphuncle
(C) A two-valved shell
(D) A lophophore for feeding

205. The 'Age of Fishes' is a name commonly given to which geological period?
(A) Silurian
(B) Cambrian
(C) Devonian
(D) Permian

206. A micropaleontologist uses microfossils for biostratigraphy. The ideal microfossil for this purpose should be:
(A) Geographically restricted and exceptionally long-ranging.
(B) Extremely slow to evolve and exclusively benthic.
(C) Large enough to be clearly visible without a microscope.
(D) Abundant, short-ranging, and geographically widespread.

207. The first appearance of Gymnosperms in the geological record occurred in the:
(A) Late Devonian
(B) Early Cambrian
(C) Cretaceous
(D) Paleogene

208. Evaluate the following statements regarding lithostratigraphic units:
Statement I : A lithostratigraphic unit is defined by its observable physical attributes.
Statement II : The boundaries of a lithostratigraphic unit can be diachronous, meaning they can cut across time lines.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

209. The Eastern Ghats Mobile Belt of India is known for its high-grade metamorphic rocks such as charnockites and:
(A) Banded Iron Formations
(B) Khondalites
(C) Stromatolitic Limestones
(D) Unaltered Sandstones

210. Which of the following statements about the Vindhyan Supergroup is incorrect?
(A) It contains rich deposits of metallurgical coal.
(B) It is of Proterozoic age.
(C) It is largely unmetamorphosed and horizontally bedded.
(D) It is famous for building stones like sandstone and limestone.

211. The 'Po Series' and 'Fenestella Shales' are Palaeozoic formations characteristic of which region?
(A) Kutch
(B) Narmada Valley
(C) Kashmir and Spiti
(D) Assam

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(B) Dharwar Supergroup - Gold (Kolar)
(C) Gondwana Supergroup - Diamonds (Panna)
(D) Deccan Traps - Marine fossils

167. The term 'stromatolite' refers to:
(A) A type of meteoritic iron
(B) A fossilized dinosaur egg
(C) A type of volcanic bomb
(D) A layered sedimentary structure created by cyanobacteria

168. The famous marine fossil beds of the Bagh area in the Narmada valley are of which age?
(A) Cretaceous
(B) Jurassic
(C) Triassic
(D) Permian

169. Consider the following statements about the Gondwana Supergroup:
1. It is a fluvio-lacustrine deposit.
2. The sequence starts with glacial deposits of the Talchir formation.
3. The flora is characterized by the dominance of Angiosperms.

Which of the above statement(s) is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

170. Which feature is used to distinguish between the two valves of a brachiopod shell?
(A) One valve (brachial) contains the lophophore supports, the other (pedicle) has the pedicle opening.
(B) One valve has a siphuncle, the other does not.
(C) One valve is significantly larger than the other.
(D) One valve is coiled, the other is flat.

171. The extinction of dinosaurs, ammonites, and many other species at the end of the Cretaceous is known as the:
(A) Permian-Triassic (P-T) extinction
(B) Late Devonian extinction
(C) Ordovician-Silurian extinction
(D) Cretaceous-Paleogene (K-Pg) extinction

172. The presence of 'Nummulites' fossils in a limestone is a clear indicator that the rock is of what age?
(A) Cretaceous
(B) Eocene (Tertiary)
(C) Jurassic
(D) Permian

173. The stratigraphic succession in the Spiti valley is significant because it represents a continuous record of which era?
(A) The entire Cenozoic
(B) The entire Mesozoic
(C) The Palaeozoic and Mesozoic
(D) The late Proterozoic

174. In a geological map, the 'Delhi Supergroup' and 'Aravalli Supergroup' would be located in which region of India?
(A) South India
(B) Eastern India
(C) Central India
(D) Northwestern India (Rajasthan)

175. The 'Semri Group' is the lowermost subdivision of which major stratigraphic unit?
(A) Vindhyan Supergroup
(B) Cuddapah Supergroup
(C) Gondwana Supergroup
(D) Marwar Supergroup

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176. Which of the following is an incorrect statement regarding the Deccan Traps?
(A) They are one of the largest volcanic provinces in the world.
(B) The lava is predominantly rhyolitic in composition.
(C) The eruptions occurred at the end of the Cretaceous period.
(D) The flows are separated by sedimentary beds called inter-trappeans.

177. If a geologist finds a rock sequence with the fossil succession of Talchir Tillite, Barakar Formation, and Raniganj Formation, they are studying rocks of the:
(A) Cuddapah Supergroup
(B) Lower Gondwana Group
(C) Vindhyan Supergroup
(D) Upper Gondwana Group

223. The Cuddapah basin is a classic example of a/an:
(A) Proterozoic intracratonic basin
(B) Active volcanic arc
(C) Foreland basin
(D) Rift valley basin

224. Which formation marks the onset of glacial conditions in the Gondwana sequence?
(A) Barakar Formation
(B) Talchir Formation
(C) Raniganj Formation
(D) Panchet Formation

225. Identify the stratigraphic unit based on the following geological observation:
A geologist finds a thick sequence of fluvial sandstones, mudstones, and conglomerates containing fossils of large mammals like elephants and horses.
(A) Gondwana Supergroup
(B) Siwalik Group
(C) Vindhyan Supergroup
(D) Cuddapah Supergroup

226. What is the primary use of index fossils in geology?
(A) For correlation and dating of rock strata
(B) To determine the mineral composition of a rock
(C) To determine the palaeoclimate
(D) To assess the economic value of a rock

227. The body of a trilobite is divided antero-posteriorly into:
(A) Axial lobe and pleural lobes
(B) Umbo, hinge, and commissure
(C) Cephalon, thorax, and pygidium
(D) Calyx, stem, and holdfast

228. Evaluate the following statements regarding brachiopods and lamellibranchs:
Statement I : Brachiopods have two unequal valves, and the plane of symmetry is perpendicular to the hinge line.
Statement II : Lamellibranchs have two equal valves, and the plane of symmetry is parallel to the hinge line.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

229. Consider the following statements regarding Mesozoic stratigraphy:
1. The Triassic of Spiti is famous for ammonites like Ceratites.
2. The Jurassic of Kutch is well known for its rich ammonite fauna.
3. The Cretaceous of South India (Trichinopoly) contains abundant marine invertebrate fossils.

Which of the above statement(s) is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

230. The appearance of the first true mammals occurred in which geological period?
(A) Late Cretaceous
(B) Late Triassic
(C) Paleocene
(D) Permian

231. The 'Gondwana Flora' is distinctly different from the 'European Carboniferous Flora'. The Gondwana Flora is also known as:
(A) The Angiosperm Flora
(B) The Ptillophyllum Flora
(C) The Lepidodendron Flora
(D) The Glossopteris Flora

232. Which of the following is a geochronologic unit, representing a span of time?
(A) Era
(B) Series
(C) Stage
(D) System

233. The 'Dalma lavas' are a prominent volcanic sequence within the Archaean-Proterozoic rocks of the:
(A) Dharwar Craton
(B) Aravalli Mountain Belt
(C) Singhbhum Craton
(D) Bundelkhand Craton

234. The Saline Formation of the Salt Range, consisting of salt, marl, and gypsum, is controversial due to its uncertain:
(A) Age and structural position

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188. The Jurassic of Kutch is a classic area for the study of Mesozoic stratigraphy in India. It is particularly famous for its well-preserved:
(A) Trilobites
(B) Ammonites
(C) Graptolites
(D) Dinosaur eggs

189. A key difference between regular and irregular echinoids is the:
(A) Composition of their test
(B) Number of ambulacral plates
(C) Position of the anus and peristome
(D) Presence or absence of spines

190. Which of the following is NOT a class within the phylum Mollusca?
(A) Gastropoda
(B) Cephalopoda
(C) Lamellibranchia
(D) Brachiopoda

191. The succession of vertebrate life shows that birds evolved from:
(A) Theropod dinosaurs
(B) Pterosaurs
(C) Amphibians
(D) Marine reptiles

192. Which of the following is a key characteristic of the Gondwana Flora?
(A) Presence of large flowering trees
(B) Dominance of the tongue-shaped leaf 'Glossopteris'
(C) Abundance of cycads and conifers similar to modern types
(D) Presence of early grasses and herbs

193. The principle that states that fossils succeed each other in a definite and determinable order, and therefore any time period can be recognized by its fossil content, is the principle of:
(A) Original horizontality
(B) Faunal succession
(C) Superposition
(D) Cross-cutting relationships

194. Which of the following is the highest-ranking lithostratigraphic unit?
(A) Supergroup
(B) Formation
(C) Group
(D) Member

195. Consider the following statements about Indian stratigraphy:
1. The Kolar Gold Fields are located in the Dharwar Supergroup.
2. The Vindhyan Supergroup is a major source of Indian coal.
3. The Cuddapah Supergroup is known for Barytes deposits.

Which of the above statement(s) is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

196. The stratigraphic section at Spiti is an excellent example of a Tethyan Himalayan sequence. What does 'Tethyan' refer to?
(A) A sequence of volcanic rocks
(B) A sequence of terrestrial, river-deposited sediments
(C) Highly metamorphosed rocks of the Himalayan core
(D) Sediments deposited in the ancient Tethys Sea

197. The 'Trichinopoly Group' in South India is renowned for its rich fossil assemblage of which age?
(A) Jurassic
(B) Permian
(C) Cretaceous
(D) Eocene

198. The classification of the Gondwana Supergroup is primarily based on:
(A) The presence of marine fossils
(B) Lithology and floral content
(C) The degree of metamorphism
(D) The type of volcanic rocks present

199. The Digboi oil field, the oldest in India, produces oil from which geological formation?
(A) Barakar Formation
(B) Lameta Beds
(C) Vindhyan Limestone
(D) Tipam Sandstone (Tertiary)

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(D) A is false but R is true.

134. Which of the following is a characteristic fossil of the Siwalik Group?
(A) Nummulites
(B) Sivapithecus
(C) Glossopteris
(D) Ceratites

135. A mould and a cast are two types of fossil preservation. What is the difference between them?
(A) A mould represents the original cavity, whereas a cast refers specifically to the infilling of that cavity.
(B) A mould is a type of altered hard part, whereas a cast consists of completely unaltered biological material.
(C) A mould is categorized as a trace fossil, whereas a cast is always classified as a genuine body fossil.
(D) A mould is an impression of the organism, while a cast is formed when the mould is filled with sediment.

136. Which part of the trilobite exoskeleton is formed by the fusion of cephalic segments?
(A) Cephalon
(B) Pygidium
(C) Thorax
(D) Glabella

137. The 'Aristotle's Lantern' is a complex jaw apparatus found in which group of organisms?
(A) Brachiopods
(B) Lamellibranchs
(C) Regular Echinoids
(D) Ammonites

138. Consider the following statements about molluscan fossils:
1. Gastropods are characterized by a single, usually coiled shell and undergo torsion.
2. Cephalopods like ammonites were free-swimming predators with chambered shells.
3. Lamellibranchs (bivalves) have a shell made of two valves that are mirror images of each other.

Which of the above statement(s) is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

139. The geological history of vertebrates indicates that the first land-dwelling vertebrates were:
(A) Reptiles
(B) Mammals
(C) Birds
(D) Amphibians

140. Which of the following is a key application of micropaleontology in the exploration for fossil fuels?
(A) To directly detect hydrocarbons using microfossils.
(B) For high-resolution biostratigraphic correlation of well sections.
(C) To determine the porosity of reservoir rocks.
(D) To measure the thermal maturity of source rocks using conodonts.

141. The dominant flora of the Mesozoic Era, which served as food for many dinosaurs, was primarily composed of:
(A) Grasses and flowering plants
(B) Mosses and lichens
(C) Gymnosperms (conifers, cycads) and ferns
(D) Algae and fungi

142. A chronostratigraphic unit is a body of rock, whereas the time equivalent for its deposition is a:
(A) Biostratigraphic unit
(B) Lithostratigraphic unit
(C) Sequence stratigraphic unit
(D) Geochronologic unit

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143. The 'Closepet Granite' is a prominent intrusive body within the Archaean terrain of:
(A) The Dharwar Craton
(B) The Bundelkhand Craton
(C) The Singhbhum Craton
(D) The Aravalli Mountain Belt

144. Diamondiferous conglomerates are found in the Vindhyan Supergroup, particularly in the:
(A) Bhander Group
(B) Rewa Group
(C) Kaimur Group
(D) Semri Group

212. A geologist finds rock layers containing ammonites, belemnites, and oysters. The most probable age of these rocks is:
(A) Palaeozoic
(B) Cenozoic
(C) Proterozoic
(D) Mesozoic

213. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option:
Assertion (A) : The Siwalik Group is composed of thick molasses deposits.
Reason (R) : These sediments were derived from the erosion of the rapidly rising Himalayan mountains and deposited in a foreland basin.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

214. The 'K-T Boundary' is a geological signature, usually a thin band of clay, that marks the end of the Cretaceous Period and the beginning of the:
(A) Jurassic Period
(B) Paleogene Period
(C) Permian Period
(D) Proterozoic Eon

215. The preservation of a leaf as a thin dark film on a bedding plane is an example of:
(A) Permineralization
(B) A mold
(C) A cast
(D) Carbonization

216. Which of the following is NOT a major extinct group of invertebrates?
(A) Scleractinian corals
(B) Trilobites
(C) Graptolites
(D) Rugose corals

217. Match the items in List I with those in List II and select the correct option:
List I: (Fossil Genus)
P. Perisphinctes
Q. Productus
R. Paradoxides
S. Monograptus
List II: (Group)
1. Trilobite
2. Graptolite
3. Brachiopod
4. Ammonite
(A) P-1, Q-2, R-3, S-4
(B) P-4, Q-3, R-1, S-2
(C) P-4, Q-1, R-3, S-2
(D) P-2, Q-3, R-1, S-2

218. The transition from fish to amphibians was marked by the evolution of:
(A) Lungs and limbs capable of supporting the body on land.
(B) Jaws and teeth adapted for a varied predatory diet.
(C) A bony internal skeleton for complex body movement.
(D) A streamlined body for significantly faster swimming speeds.

219. The two main groups of foraminifera, based on their mode of life, are:
(A) Calcareous and Agglutinated
(B) Coiled and Uncoiled
(C) Simple and Complex
(D) Planktonic and Benthic

220. The concept that geological processes operating today are the same as those that operated in the past is known as:
(A) Catastrophism
(B) Uniformitarianism
(C) Neptunism
(D) Plutonism

221. The tectonic framework of India is comprised of the Peninsular Shield, the Himalayas, and the:
(A) Deccan Plateau
(B) Western Ghats
(C) Indo-Gangetic Plains
(D) Eastern Ghats

222. The Archaean rocks of South India are broadly classified into greenstone belts and:
(A) Unaltered sedimentary basins
(B) Flood basalt provinces
(C) Foreland basins
(D) Granulite-gneiss terrains

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155. What is the fundamental criterion for defining the boundaries of a biostratigraphic zone?
(A) A change in rock type
(B) A major unconformity
(C) A reversal in magnetic polarity
(D) The first appearance, last appearance, or range of one or more fossil taxa

156. The economic importance of Archaean rocks in Jharkhand and Orissa is primarily related to their rich deposits of:
(A) Petroleum and natural gas
(B) Iron, manganese, and chromite
(C) Rock salt and gypsum
(D) Diamonds and building stones

157. Evaluate the following statements regarding the Cuddapah Supergroup:
Statement I : The Cuddapah Supergroup is a Proterozoic basin located on the east coast of India.
Statement II : The sediments of the Cuddapah Supergroup are highly metamorphosed and intensely folded throughout the basin.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

158. The 'Haimanta Group' and 'Kanawar Group' are Palaeozoic stratigraphic units found in:
(A) The Salt Range
(B) The Kutch Basin
(C) The Narmada Valley
(D) The Spiti Valley

159. The Cretaceous succession of South India, particularly around Trichinopoly, is a classic example of a:
(A) Marine transgressive sequence
(B) Fluvial depositional system
(C) Glacial depositional system
(D) Volcanic caldera

160. The 'Damuda Group' is the primary coal-bearing unit within the Gondwana Supergroup. It includes which famous coal formations?
(A) Talchir and Karharbari
(B) Barakar and Raniganj
(C) Panchet and Mahadeva
(D) Tipam and Surma

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161. Which of the following is NOT a typical mode of fossilization?
(A) Permineralization
(B) Sublimation
(C) Carbonization
(D) Replacement

162. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option:
Assertion (A) : Graptolites are excellent index fossils for the Ordovician and Silurian periods.
Reason (R) : They were planktonic, experienced rapid evolution, and had a wide geographic distribution, fulfilling all the criteria for a good index fossil.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

163. The classification of cephalopods into Nautiloids and Ammonoids is based primarily on:
(A) The composition of the shell.
(B) The presence or absence of a lophophore.
(C) The nature of the suture line and the position of the siphuncle.
(D) The coiling direction of the shell.

164. What is the geological age of the rock formations that host the major oil and gas reserves in Assam?
(A) Archaean
(B) Mesozoic
(C) Proterozoic
(D) Tertiary

165. The concept of sequence stratigraphy" integrates seismic data, well logs, and outcrop data to understand depositional systems in the context of:
(A) Magnetic reversals
(B) Volcanic activity
(C) Changes in sea level
(D) Plate tectonics

166. Which one of the following identifies a correct pair?
(A) Vindhyan Supergroup - Major coal deposits

(B) Thickness
(C) Economic value
(D) Fossil content

235. The 'Spiti Shales' are a famous Jurassic formation in the Spiti valley, known for their:
(A) Well-preserved dinosaur skeletons
(B) Thick coal seams
(C) Stromatolitic structures
(D) Abundant, well-preserved ammonites in nodules

236. The term 'inter-trappean beds' refers to:
(A) The coal seams within the Gondwana Supergroup
(B) The sedimentary layers between basalt flows of the Deccan Traps
(C) The shale layers within the Vindhyan Supergroup
(D) The ash beds within the Siwalik Group

237. The 'Surma Valley' in Northeast India is known for its thick sequence of Tertiary sediments, which are prospective for:
(A) Diamonds
(B) Gold
(C) Hydrocarbons
(D) Iron ore

238. What is the fundamental difference between body fossils and trace fossils?
(A) Body fossils are preserved in sedimentary rocks, while trace fossils are in igneous rocks.
(B) Body fossils are large, while trace fossils are microscopic.
(C) Body fossils are from animals, while trace fossils are from plants.
(D) Body fossils are remains of the organism itself, while trace fossils are records of its activity.

239. The radial plates that form the skeleton of a coral polyp are called:
(A) Septa
(B) Tabulae
(C) Dissepiments
(D) Theca

240. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option:
Assertion (A) : Nautiloids have a simple, concave suture line.
Reason (R) : In contrast, ammonoids evolved complex suture lines, which increased the strength of the shell and provided more surface area for muscle attachment.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

241. Foraminiferal tests with walls made of cemented foreign particles are described as:
(A) Porcelaneous
(B) Agglutinated
(C) Hyaline
(D) Microgranular

242. The Law of Superposition" is a fundamental principle of:
(A) Stratigraphy
(B) Palaeontology
(C) Petrology
(D) Structural Geology

243. The Dharwar Supergroup in Karnataka is economically important for all of the following EXCEPT:
(A) Gold
(B) Iron Ore
(C) Petroleum
(D) Manganese

244. Identify the stratigraphic unit based on the following geological observation:
A geologist encounters a sequence of rocks characterized by purple shales, glauconitic sandstones, and stromatolitic limestones, with the 'Rohtas Limestone' at the top.
(A) Nallamalai Group of the Cuddapah Supergroup
(B) Barakar Formation of the Gondwana Supergroup
(C) Umia Series of the Jurassic of Kutch
(D) Semri Group of the Vindhyan Supergroup

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Supergroup is globally famous for its massive coal reserves, which power much of India. Finally, the Cuddapah Supergroup is a major producer of minerals like barytes and asbestos.

28. (B) Ammonites
The Jurassic succession in the Kutch region of Gujarat is one of the most fossiliferous Mesozoic sequences in India. It is particularly renowned for its vast and diverse collection of ammonites, which are extinct marine cephalopods with coiled shells. These fossils are vital for biostratigraphic correlation, allowing geologists to accurately date the different layers of the Kutch sedimentary sequence.

29. (C) A rich assemblage of marine invertebrate fossils
The Trichinopoly area in the Cauvery Basin of South India is famous for its Cretaceous sedimentary rocks. These strata record a series of marine transgressions and contain a spectacular diversity of marine invertebrate fossils. The assemblage includes ammonites, nautiloids, gastropods, and bivalves, making it a critical locality for studying Cretaceous marine ecosystems and global sea-level changes.

30. (D) Narmada Valley
The Bagh Beds are a series of marine sedimentary rocks deposited during the Cretaceous Period. They are found along the Narmada Valley in central India. These beds represent a short-lived marine transgression into the interior of the Indian Peninsula. They are characterized by a rich fauna of fossilized echinoids, lamellibranchs, and ammonites, which provide evidence for ancient sea connections.

31. (A) They are a thick sequence of marine shales.
The Lameta Beds are a Late Cretaceous stratigraphic unit primarily found in central India. Contrary to being marine shales, they are mostly freshwater and terrestrial sediments. These beds are internationally significant for their paleontological content, specifically the discovery of numerous dinosaur skeletal remains and eggs, and they frequently occur immediately beneath the volcanic flows of the Deccan Traps.

32. (B) A large igneous province formed by fissure-type volcanic eruptions
The Deccan Traps constitute one of the world's largest igneous provinces, covering vast portions of central and western India. They were formed by massive fissure eruptions of basaltic lava during the Late Cretaceous and Early Tertiary. These eruptions created a thick sequence of horizontal lava flows, or traps, which have significantly shaped the topography and geology of the peninsula.

33. (B) Gondwana Supergroup
The presence of Glossopteris, Gangamopteris, and Vertebraria is a diagnostic feature of the Gondwana flora. These fossils are typically found in alternating layers of sandstone and shale that also contain thick coal seams. This specific combination of terrestrial plant life and sedimentary characteristics is unique to the Gondwana Supergroup, which represents a long period of continental deposition in India.

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34. (A) Central India (Madhya Pradesh/Andhra Pradesh)
The term Gondwana was originally proposed by H.B. Medlicott to describe a thick sequence of coal-bearing sedimentary rocks in India. It was named after the Gondwana region in central India, which was the ancestral home of the Gond tribes. This name was later adopted to describe the ancient supercontinent that included India, Africa, South America, and Antarctica.

35. (A) Both A and R are true and R is the correct explanation of A.
The Gondwana Supergroup sediments were deposited in linear, fault-bounded troughs known as grabens. This deposition was driven by tensional tectonics associated with the early stages of the rifting of the Gondwanaland supercontinent. These structural basins allowed for the accumulation of thick sequences of fluvial and lacustrine sediments, including the vast coal deposits found in modern-day India.

36. (D) Coal
The Gondwana Supergroup is of immense economic importance to India because it contains nearly all of the country's metallurgical and thermal coal reserves. These coal seams were formed from the accumulation of massive

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257. Match the items in List I with those in List II and select the correct option:
List I: (Geological Formation)
P. Siwalik Group
Q. Cretaceous of Trichinopoly
R. Jurassic of Kutch
S. Permian of Salt Range
List II: (Characteristic Fossil)
1. Productus
2. Stegodon
3. Pachydiscus
4. Perisphinctes
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-3, R-4, S-1
(C) P-2, Q-4, R-1, S-3
(D) P-3, Q-1, R-4, S-2

258. The Bagh Beds of Cretaceous age are an example of a marine transgression over which part of India?
(A) The Peninsular shield (Narmada Valley)
(B) The Himalayan region
(C) The Bengal basin
(D) The Rajasthan desert

259. What is the palaeoclimatic significance of the Talchir Boulder Bed at the base of the Gondwana Supergroup?
(A) It indicates a hot, arid climate.
(B) It signifies a major marine transgression.
(C) It provides evidence for a widespread Permo-Carboniferous glaciation.
(D) It points to a period of intense volcanic activity.

260. Consider the following statements about index fossils:
1. An index fossil should have a long geological range.
2. An index fossil should have a wide geographical distribution.
3. An index fossil should be abundant and easily recognizable.
Which of the above statement(s) is/are correct for an ideal index fossil?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

261. The feeding organ in a brachiopod is the:
(A) Radula
(B) Aristotle's Lantern
(C) Lophophore
(D) Siphuncle

262. The main difference in shell symmetry between a typical brachiopod and a typical lamellibranch is:
(A) Brachiopods are equivalved, lamellibranchs are inequivalved.
(B) Brachiopods are equilateral, lamellibranchs are inequilateral.
(C) Brachiopods have phosphatic shells, lamellibranchs have calcareous shells.
(D) Brachiopods are always attached, lamellibranchs are always free-swimming.

263. The first vertebrates to appear in the fossil record were:
(A) Jawed fishes
(B) Amphibians
(C) Sharks
(D) Jawless fishes (Agnathans)

264. Palynology is the study of:
(A) Fossil spores, pollen, and other palynomorphs
(B) Fossil wood and leaves
(C) Foraminifera and Ostracods
(D) Trace fossils like burrows and tracks

265. Magneto-stratigraphy is a correlation tool based on the record of:
(A) Fossil magnetism
(B) The magnetic properties of individual minerals
(C) Earth's magnetic field reversals preserved in rocks
(D) The alignment of fossils by magnetic fields

266. Which one of the following is NOT a major Archaean craton in India?
(A) Marwar
(B) Dharwar
(C) Singhbhum
(D) Bastar

267. The 'Great Eparchaean Unconformity' separates:
(A) The Vindhyans from the Gondwanas
(B) The Mesozoic from the Cenozoic

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245. The 'Zewan beds' of Kashmir are famous for their rich fossil fauna of which age?
(A) Triassic
(B) Jurassic
(C) Permian
(D) Cretaceous

246. Arrange the following events in the history of life in chronological order from oldest to most recent:
1. Extinction of dinosaurs
2. First appearance of Trilobites
3. First appearance of humans
4. First appearance of land plants

Which of the following is the correct sequence?
(A) 2, 4, 1, 3
(B) 4, 2, 1, 3
(C) 2, 1, 4, 3
(D) 1, 2, 3, 4

247. The 'Ptillophyllum flora' is characteristic of which stratigraphic interval in India?
(A) Lower Gondwana
(B) Tertiary of Assam
(C) Siwaliks
(D) Upper Gondwana (Jurassic)

248. The study of the morphology, classification, and geological history of Graptolites is important for the biostratigraphy of which era?
(A) Palaeozoic
(B) Mesozoic
(C) Cenozoic
(D) Proterozoic

249. Which of the following is an example of a trace fossil?
(A) A petrified wood
(B) An ammonite shell
(C) A dinosaur footprint
(D) A shark tooth

250. The siphuncle in a cephalopod shell is a tube that connects the chambers. Its primary function was likely to:
(A) Control buoyancy by regulating gas and fluid in the chambers
(B) Expel ink for defense
(C) Serve as a conduit for the digestive tract
(D) House the reproductive organs

251. The vertebrate group that first developed the amniotic egg, allowing reproduction away from water, was the:
(A) Amphibians
(B) Fish
(C) Birds
(D) Reptiles

252. The classification of foraminifera into different orders is primarily based on:
(A) The size of the test
(B) The wall composition and structure of the test
(C) The mode of life (benthic or planktonic)
(D) The geological age in which they are found

253. The appearance of grasses and the co-evolutionary radiation of grazing mammals are key events of which era?
(A) Palaeozoic
(B) Mesozoic
(C) Cenozoic
(D) Proterozoic

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254. Which of the following correctly pairs a chronostratigraphic unit with its corresponding geochronologic unit?
(A) System - Era
(B) Series - Period
(C) Eonothem - Period
(D) Stage - Age

255. The Archaean cratons of India (Dharwar, Singhbhum, Bundelkhand) are separated by:
(A) Proterozoic mobile belts
(B) Cenozoic ocean basins
(C) Mesozoic flood basalts
(D) Palaeozoic glacial deposits

256. Evaluate the following statements regarding Indian geology:
Statement I : The Vindhyan basin is a Purana basin of India.
Statement II : The Vindhyan rocks are famous for providing high-quality coking coal.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

(A) Trilobites became extinct at the end of the Permian.
(B) Graptolites are good index fossils for the Ordovician-Silurian.
(C) Echinoids have a skeleton made of calcite plates.
(D) Ammonites first appeared in the Cambrian.

280. The evolution of the horse, showing a reduction in the number of toes and an increase in the size and complexity of teeth, is well-documented from the fossil record of the Cenozoic, including the:
(A) Siwalik Group
(B) Gondwana beds
(C) Deccan inter-trappeans
(D) Spiti shales

281. The term 'palynofacies' refers to:
(A) The total assemblage of fossil pollen and spores in a sediment
(B) A rock layer defined by a single type of pollen
(C) The total organic matter (including palynomorphs) in a sedimentary rock, used to interpret depositional environments
(D) The study of modern pollen to understand ancient flora

282. Which principle states that sedimentary layers are deposited in flat-lying layers?
(A) Principle of Original Horizontality
(B) Principle of Superposition
(C) Principle of Faunal Succession
(D) Principle of Lateral Continuity

283. Evaluate the following statements regarding the tectonic regions of India:
Statement I : The Indian shield is a stable cratonic block that has not undergone major deformation since the Precambrian.
Statement II : The Himalayas are a young, tectonically active mountain range formed by the collision of the Indian and Eurasian plates.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true but Statement II is false.
(D) Statement I is false but Statement II is true.

284. Consider the following statements about Proterozoic basins of India:
1. The Cuddapah basin has a distinct crescent shape.
2. The Vindhyan basin is known for stromatolite-bearing limestones.
3. Both basins are major repositories of petroleum in India.

Which of the above statement(s) is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

285. The Mesozoic era is divided into which three periods?
(A) Cambrian, Ordovician, Silurian
(B) Permian, Carboniferous, Devonian
(C) Triassic, Jurassic, Cretaceous
(D) Paleogene, Neogene, Quaternary

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286. A mass extinction event far greater than the one that killed the dinosaurs occurred at the end of which period?
(A) Cretaceous
(B) Devonian
(C) Ordovician
(D) Permian

287. Match the items in List I with those in List II and select the correct option:
List I: (Indian Stratigraphic Unit)
P. Dharwar Supergroup
Q. Siwalik Group
R. Vindhyan Supergroup
S. Gondwana Supergroup
List II: (Region)
1. Central India (Vindhya Range)
2. Himalayan Foothills
3. Peninsular River Valleys (e.g., Damodar, Godavari)
4. South India (Karnataka)
(A) P-1, Q-2, R-3, S-4
(B) P-4, Q-3, R-1, S-2
(C) P-4, Q-2, R-1, S-3
(D) P-2, Q-3, R-1, S-4

288. The presence of 'caliche' or palaeosol horizons within the Siwalik sequence is indicative of:
(A) Deep marine depositional environments
(B) Periods of non-deposition and soil formation on ancient floodplains
(C) Intense volcanic activity and ash fall

Gangetic Plains consist of a deep foreland basin. While the Andaman-Nicobar Arc is tectonically significant, it is not traditionally listed as one of these primary divisions.

10. (A) 1 and 2 only
In stratigraphic terminology, a formation is the basic unit used for lithological mapping. Similarly, a system is the chronostratigraphic unit that represents the rocks formed during a geochronologic period. However, an assemblage zone is a biostratigraphic unit defined by its fossil content, not a lithostratigraphic unit, which is instead defined by physical rock characteristics like mineralogy and texture.

11. (D) Copper, Uranium, and Iron
The Singhbhum region of Jharkhand is a critical geological terrain known for its vast mineral wealth. It hosts the Singhbhum Shear Zone, which contains significant concentrations of copper and uranium. Additionally, the region is famous for the Iron Ore Group, which provides high-grade hematite deposits that are essential for the metallurgical industries located throughout eastern India.

12. (B) The absence of definitive life forms
The term azoic refers to geological periods characterized by an absence of life forms in the rock record. In the context of the Indian Archaean history, this classification suggests that the environmental conditions or the subsequent metamorphic processes were not conducive to the preservation of recognizable fossils, indicating a time before complex organisms appeared in any significant abundance.

13. (C) Rich gold deposits in the Kolar region
The Dharwar Supergroup represents a significant portion of the Archaean crust in South India, specifically within the Karnataka region. This geological sequence is economically renowned for its prolific gold mineralization, particularly within the Kolar Gold Fields. These deposits are typically associated with ancient greenstone belts that underwent complex structural and metamorphic changes during the long Precambrian history.

14. (D) Khondalite Group - Orissa (Eastern Ghats)
The Khondalite Group is a distinctive suite of high-grade metamorphic rocks, primarily garnet-sillimanite-graphite schists and gneisses. These rocks are characteristic of the Eastern Ghats Mobile Belt, which spans across parts of Orissa and Andhra Pradesh. They represent ancient sedimentary sequences that were subjected to intense temperature and pressure conditions during Proterozoic orogenic events on the Indian shield.

15. (A) The Archaean and the Proterozoic
The Precambrian spans the vast majority of Earth's history, from its initial formation until the start of the Cambrian period. In Indian stratigraphy, this long interval is broadly divided into the Archaean and Proterozoic eons. These divisions are based on fundamental differences in crustal evolution, tectonic styles, and the emergence of early life forms like microbial stromatolites.

16. (B) 4, 2, 1, 3
The chronological sequence of geological eons begins with the Hadean, representing the earliest formation of the Earth. This was followed by the Archaean, during which the first crustal blocks and life emerged. The Proterozoic followed, marked by atmospheric oxygenation, and finally, the Phanerozoic began, characterized by the proliferation of diverse, multicellular fossil life throughout the global record.

17. (B) Andhra Pradesh
The Cuddapah Supergroup constitutes a major Proterozoic sedimentary basin located in the eastern part of the Indian Peninsula, primarily within Andhra Pradesh. This crescent-shaped basin contains a thick sequence of relatively undeformed sedimentary rocks, including quartzites, shales, and limestones. It represents a significant period of intracratonic basin development following the stabilization of the ancient Archaean crystalline basement.

18. (A) Both Statement I and Statement II are true.
The Cuddapah and Vindhyan systems represent two of India's most significant Purana basins. The Cuddapah basin displays a characteristic crescent shape and contains relatively unmetamorphosed sediments. Stratigraphically,

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ANSWERS

1. (B) Formation
Lithostratigraphy is the branch of stratigraphy that focuses on the physical and petrographic characteristics of rock layers. Within this hierarchical system, the formation serves as the fundamental mapping unit because it is large enough to be delineated on a standard geological map while maintaining a consistent lithological character throughout its entire extent.

2. (A) Both Statement I and Statement II are true.
Bio-stratigraphic units are defined as bodies of rock strata characterized by their unique fossil content. These units, known as biozones, are based on the presence, absence, or abundance of specific taxa. Because fossils represent biological events in time, these zones are independent of lithological changes and can frequently cross different rock types and formation boundaries.

3. (C) Period
Geochronologic units are divisions of geological time rather than physical rock bodies. A period represents a significant interval within an era, such as the Cretaceous or Jurassic. It corresponds exactly to a chronostratigraphic system, which consists of all the rocks formed globally during that specific time interval. Other units like systems and series represent rock strata.

4. (D) Sequence stratigraphy
Sequence stratigraphy involves the study of genetically related rock strata bounded by significant surfaces of erosion or non-deposition, known as unconformities. This branch of geology focuses on how sedimentary packages respond to changes in sea level and sediment supply. It is particularly useful for analyzing large-scale cycles of marine transgressions and regressions within a basin.

5. (C) Chronostratigraphic units are defined primarily on the basis of their inherent fossil content.
Chronostratigraphic units represent the material bodies of rock that formed during a specific interval of geological time. While fossil content is often used to recognize and correlate these units, they are defined by time boundaries rather than biological characteristics alone. Their boundaries are theoretically synchronous worldwide, representing the same moment in time regardless of the local rock types.

6. (A) Both A and R are true and R is the correct explanation of A.
Stratigraphic correlation is the process of establishing the equivalence of rock units across different geographic areas. Index fossils play a crucial role in this process because they lived for a short duration and had a wide distribution. Therefore, finding identical index fossils in separate units provides strong evidence that those rocks were deposited during the same time interval.

7. (D) Magneto-stratigraphy
Magneto-stratigraphy is a specialized branch of stratigraphy that utilizes the remnant magnetism preserved in rocks. As minerals cool or settle, they record the orientation and polarity of the Earth's magnetic field at that time. By identifying sequences of normal and reversed polarity, geologists can establish a chronological framework and correlate rock sequences across vast global distances.

8. (A) P-3, Q-1, R-2, S-4
Stratigraphic classification uses different units to describe rock layers. A group is a lithostratigraphic unit comprising several formations. A biozone is defined by fossil content and belongs to biostratigraphy. A period is a geochronologic unit representing time, while a system is its chronostratigraphic equivalent, representing the actual rocks deposited during that specific time interval.

9. (C) The Andaman-Nicobar Volcanic Arc
The Indian subcontinent is geologically divided into three major tectonic provinces. The Peninsular Shield is a stable cratonic block, while the Extra-Peninsular Himalayan Region represents a young mountain belt. The Indo-

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(C) The Palaeozoic from the Mesozoic
(D) The Archaean basement from the Proterozoic sedimentary cover

268. The Phanerozoic fossil record begins in the Cambrian with an event known as the Cambrian Explosion". This refers to:
(A) A massive meteorite impact.
(B) The rapid appearance and diversification of most major animal phyla.
(C) The first appearance of land plants.
(D) A major volcanic eruption that covered the globe in ash.

269. The Cretaceous formations of South India (Uttatur, Trichinopoly, Ariyalur Groups) are economically important for their deposits of:
(A) Coal and iron
(B) Gold and diamonds
(C) Limestone, gypsum, and celestite
(D) Petroleum and natural gas

270. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option:
Assertion (A) : The Siwalik hills are known for their rich vertebrate fossil record.
Reason (R) : The rapid sedimentation in the fluvial environment of the Himalayan foreland basin led to the quick burial and preservation of animal remains.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

271. An organism preserved in its entirety, with flesh, skin, and bones intact, is most likely to be found in which medium?
(A) Amber or ice
(B) Sandstone
(C) Shale
(D) Limestone

272. A key evolutionary feature of the Graptoloidea that made them successful planktonic organisms was the:
(A) Development of a robust, heavy skeleton
(B) Reduction in the number of stipes and development of a float (nema)
(C) Adoption of a benthic, rooted lifestyle
(D) Increase in the thickness of the thecae

273. The shell of a gastropod grows by adding new material at the:
(A) Apex
(B) Aperture
(C) Suture
(D) Umbilicus

274. Foraminifera are useful in palaeo-oceanographic reconstructions because the isotopic composition ($\delta^{18}O$) of their calcite tests can be used to infer:
(A) Past sea-surface temperatures
(B) Past salinity levels
(C) The age of the sediment in millions of years
(D) The direction of ocean currents

275. The division of the Precambrian into Archaean and Proterozoic is based on fundamental changes in:
(A) Faunal assemblages
(B) The Earth's magnetic field
(C) Tectonic styles and crustal evolution
(D) The dominant rock type from sedimentary to igneous

276. The 'Bhander group' is the uppermost group of the:
(A) Cuddapah Supergroup
(B) Gondwana Supergroup
(C) Dharwar Supergroup
(D) Vindhyan Supergroup

277. The Triassic rocks of Spiti are lithologically dominated by:
(A) Sandstones and conglomerates
(B) Basaltic lava flows
(C) Limestones, shales, and dolomites
(D) Gneisses and schists

278. The 'Jabalpur Formation' and 'Kota Formation' are part of the:
(A) Lower Gondwana
(B) Upper Gondwana
(C) Vindhyan Supergroup
(D) Siwalik Group

279. Which of the following is an incorrect statement?

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the Vindhyan Supergroup is considered younger than the Cuddapah Supergroup. Both sequences provide essential insights into the tectonic and environmental conditions of the Indian subcontinent during the middle to late Proterozoic.

19. (C) Building stones, cement-grade limestone, and diamonds
The Vindhyan Supergroup is a vital geological resource in India, primarily valued for its industrial minerals. It provides vast quantities of high-quality building stones, such as the sandstones used in many historic monuments. Furthermore, its extensive limestone beds are crucial for the cement industry, while specialized volcanic pipes within the sequence serve as the primary source of diamonds.

20. (A) Both A and R are true and R is the correct explanation of A.
The Vindhyan sequence is largely devoid of large, complex fossils because it was deposited during the Proterozoic Eon. This time interval preceded the Cambrian explosion, which was the period when diverse multicellular organisms with hard parts first appeared. Consequently, the fossil record in these rocks is dominated by microscopic life forms and layered microbial structures like stromatolites.

21. (C) Vindhyan Supergroup
The Panna region of Madhya Pradesh is internationally famous for its diamond mines. These diamonds are genetically related to kimberlite-like volcanic pipes that intruded into the sedimentary layers of the Vindhyan Supergroup. Additionally, secondary deposits of diamonds are found within the conglomerates of the Rewa Group, which is a major stratigraphic subdivision of the greater Vindhyan sequence.

22. (B) Trilobites and Brachiopods
The Salt Range in Pakistan is a world-renowned geological site that exposes a comprehensive Palaeozoic succession. It is particularly famous for its early Cambrian strata, which contain an abundance of well-preserved marine fossils. Among these, trilobites and brachiopods are the most significant, providing critical evidence for the timing of early animal diversification within the Indian subcontinent region.

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23. (D) Cambrian and Eocene
The age of the Punjab Saline Series, or Saline Formation, in the Salt Range has been a long-standing controversy. Some geologists argue for a Cambrian age based on its position below fossiliferous Cambrian rocks. Others suggest an Eocene age, proposing that the salt was thrust under older rocks. This debate highlights the structural complexity of the region's tectonic history.

24. (D) 1, 2 and 3
Proterozoic basins in India provide diverse geological and economic insights. The Cuddapah Supergroup is divided into four major groups, including the Papaghni and Nallamalai. It is also an important source of industrial minerals like asbestos and barytes. Meanwhile, the Vindhyan Supergroup is noted for its stromatolite-bearing limestones, which indicate early microbial life in shallow marine environments.

25. (C) Complete and highly fossiliferous marine succession from Cambrian to Permian
The Spiti Valley, located in the Tethyan Himalayan belt, is often called a geological museum. It contains an exceptionally complete and well-preserved sequence of marine sedimentary rocks spanning from the Cambrian to the Permian. This succession is highly fossiliferous, providing a detailed record of Palaeozoic marine life, including diverse assemblages of trilobites, brachiopods, and other important invertebrate groups.

26. (A) Triassic
The Triassic rocks of the Spiti region are exceptionally well-represented by a thick sequence of marine sediments known as the Lilang Group. These strata are famous for their rich and diverse ammonite fauna, such as Ceratites. This fossil record is so complete and well-studied that it serves as a global reference for understanding Triassic marine life and stratigraphy.

27. (B) P-3, Q-2, R-1, S-4
Indian geological units are associated with specific economic resources. The Dharwar Supergroup is the primary source of iron and gold. The Vindhyan Supergroup provides extensive building stones like sandstone. The Gondwana

(D) Glacial conditions and ice cover

289. The five-fold (pentameral) symmetry is a hallmark of which phylum?
(A) Mollusca
(B) Echinodermata
(C) Brachiopoda
(D) Arthropoda

290. In cephalopods, the protoconch is the:
(A) First-formed embryonic chamber of the shell
(B) Muscular foot used for locomotion
(C) Hard beak-like jaw
(D) Tube connecting the chambers

291. The succession of plant life through time shows that flowering plants (Angiosperms) became dominant during the:
(A) Palaeozoic
(B) Mesozoic
(C) Cenozoic
(D) Proterozoic

292. The geological column of Indian stratigraphy places the 'Purana' group of rocks between the:
(A) Archaean and the Aryan
(B) Dravidian and the Aryan
(C) Archaean and the Cenozoic
(D) Archaean and the Dravidian

293. The economic importance of the Tertiary rocks of Assam is mainly due to their reserves of:
(A) Iron and Manganese
(B) Gold and Silver
(C) Petroleum and Coal
(D) Bauxite and Limestone

294. The extinction of the trilobites occurred at the end of the:
(A) Ordovician period
(B) Permian period
(C) Silurian period
(D) Cretaceous period

295. Which group of microfossils builds a test made of silica (SiO_2)?
(A) Foraminifera
(B) Calcareous nannofossils
(C) Ostracods with calcareous shells
(D) Radiolaria

296. A researcher studying the Archaean history of the Singhbhum region would be investigating rocks belonging to which part of India?
(A) Eastern India (B) Southern India
(C) Western India (D) Northern India

297. The 'Muth Quartzite' is a prominent and widespread formation of Devonian age found in the:
(A) Vindhyan Basin
(B) Cuddapah Basin
(C) Himalayas (Spiti, Kashmir)
(D) Gondwana Basins

298. If a sedimentary rock contains fossils of dinosaurs and ammonites, its age is most likely:
(A) Mesozoic
(B) Palaeozoic
(C) Cenozoic
(D) Proterozoic

299. In the following question, a statement of Assertion (A) is followed by a statement of Reason (R). Choose the correct option:
Assertion (A) : Microfossils like foraminifera and ostracods are extremely useful in subsurface correlation in the petroleum industry.
Reason (R) : Their small size allows them to be recovered intact from drill cuttings, and their rapid evolution provides high-resolution biostratigraphic zonation.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

300. The morphology of a regular echinoid is characterized by:
(A) Bilateral symmetry, with the mouth and anus at opposite ends.
(B) Globular shape with near-perfect pentameral symmetry, with the mouth on the lower surface and anus on the upper surface.
(C) A flattened, discoidal test adapted for burrowing.
(D) A stalked body attached to the seafloor.

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amounts of plant material in ancient river valleys and lakes. Major coalfields like Jharia, Raniganj, and Singareni are all situated within the sedimentary basins of this supergroup.

37. (C) Cold and glacial
The Talchir Formation, which lies at the base of the Gondwana Supergroup, contains distinctive boulder beds known as tillites. These deposits consist of unsorted rock fragments in a fine-grained matrix, which is characteristic of glacial activity. This evidence indicates that the Indian subcontinent experienced a cold, glacial climate during the beginning of the Gondwana period in the Early Permian.

38. (B) Presence of Angiosperms
The Gondwana flora is primarily characterized by non-flowering plants such as gymnosperms and ferns. Key genera include Glossopteris, Gangamopteris, and the root-like structure known as Vertebraria. Angiosperms, or true flowering plants, did not evolve and become dominant until much later in the Cretaceous Period. Therefore, their presence is not a characteristic feature of the typical Gondwana plant assemblages found in India.

39. (D) Coal and petroleum
The Tertiary succession in Assam is a major geological province for energy resources. It contains thick sedimentary sequences that host significant deposits of both coal and petroleum. The coal is typically found in the Barail Group, while petroleum is extracted from various sandstone reservoirs. These resources have been critical to the economic development and industrialization of the northeastern region of India.

40. (C) 1 and 2 only
Mesozoic formations in India provide rich paleontological data. The Triassic of Spiti is well known for its marine fossils like Ceratites. The Jurassic of Kutch is systematically divided into several series, including the Patcham, Chari, Katrol, and Umia. However, the Bagh Beds are of Cretaceous age, not Jurassic, representing a distinct marine transgression into the Narmada Valley region.

41. (C) Fluvial (river-deposited) sediments shed from the rising Himalayas
The Siwalik Group is a thick sequence of molasses sediments found along the foothills of the Himalayas. These sediments were deposited in a foreland basin by ancient river systems. They consist of sandstones, mudstones, and conglomerates that were derived from the erosion of the rising Himalayan mountains. This fluvial sequence provides a record of the mountain range's late-stage uplift.

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42. (A) Tertiary mammals, including primates and elephants
The Siwalik Group is internationally famous for its exceptionally rich and diverse record of vertebrate fossils. These sediments have yielded an incredible variety of Tertiary mammals, including early ancestors of modern elephants, horses, and various primates like Sivapithecus. This fossil record is vital for understanding the evolution and migration of mammalian faunas in Asia during the Neogene and Quaternary.

43. (D) Mass extinction event at the end of the Cretaceous period
The K-T Boundary, now often called the K-Pg boundary, marks the transition between the Cretaceous and Paleogene periods. It is associated with one of the most significant mass extinction events in Earth's history, which led to the disappearance of the non-avian dinosaurs and many marine groups like ammonites. Scientific debate continues regarding the relative roles of asteroid impacts and volcanism.

44. (B) Permineralization (Petrifaction)
Permineralization is a common fossilization process where mineral-rich groundwater flows through the pores and cavities of buried bones, shells, or wood. Minerals such as silica or calcite precipitate from the water and fill these spaces, eventually hardening the remains into rock. This process often preserves the internal cellular structure of the organism, providing detailed information for paleontological study and analysis.

45. (A) 4, 2, 3, 1
The chronological sequence of Indian stratigraphic units begins with the Archaean Dharwar Supergroup. This is followed by

63. (A) Gastropoda
The class Gastropoda, which includes snails and slugs, shows a wide range of shell forms. While many have the characteristic coiled shell, some primitive and specialized members possess a simple, uncoiled, cap-shaped shell. These gastropods, such as limpets, are adapted for clinging to hard surfaces in high-energy marine environments. This morphological diversity reflects the evolutionary flexibility of the gastropod body plan.

64. (B) Gastropoda
Torsion is a defining developmental process unique to the class Gastropoda. During the larval stage, the visceral mass, mantle, and shell rotate 180 degrees relative to the head and foot. This results in the gills and anus being positioned above the head. While most gastropods also have coiled shells, torsion is a separate biological event that significantly affects their anatomy and evolution.

65. (B) An elastic ligament and interlocking hinge teeth
The two valves of a lamellibranch shell are joined along the dorsal margin by a combination of structures. An elastic proteinaceous ligament acts as a spring to pull the valves open. Interlocking hinge teeth and sockets prevent the valves from sliding past each other when closed. This hinge mechanism is essential for the survival and protection of these bivalved molluscs in marine environments.

66. (A) The presence of internal chambers connected by a siphuncle.
Cephalopods are highly advanced molluscs that include modern octopuses and squids, as well as extinct ammonites. A distinguishing feature of their shells is the division into internal chambers by walls called septa. These chambers are connected by a tube known as the siphuncle, which allows the organism to regulate gas and fluid levels to control buoyancy and movement in the water.

67. (B) Goniatitic → Ceratitic → Ammonitic
Ammonoids show a clear evolutionary trend in the complexity of their suture lines, which are the lines where internal septa meet the shell. The earliest forms had simple, angular goniatitic sutures. These evolved into ceratitic sutures with frilled lobes and smooth saddles. Finally, the most complex ammonitic sutures, with both lobes and saddles being highly frilled, became dominant during the Jurassic and Cretaceous periods.

68. (A) 4, 2, 3, 1
The fossil record shows a clear chronological progression in vertebrate evolution. Fish were the first to appear in the early Palaeozoic. Amphibians evolved from fish and appeared in the Devonian. Reptiles, which could reproduce away from water, followed in the Carboniferous. Mammals appeared much later, during the Mesozoic, evolving from specialized reptilian lineages. This sequence illustrates the increasing adaptation of vertebrates to terrestrial life.

69. (C) Reptiles
The Mesozoic Era is widely known as the Age of Reptiles due to the dominance of this group on land, in the seas, and in the air. This era witnessed the rise and diversification of dinosaurs, as well as marine reptiles like ichthyosaurs and flying reptiles like pterosaurs. Reptiles were the top predators and filled most major ecological niches during this significant interval.

70. (B) Theropod dinosaurs
Modern birds are now scientifically recognized as the direct descendants of small, feathered theropod dinosaurs. The discovery of numerous fossils showing a blend of dinosaurian and avian traits, such as feathers, hollow bones, and a wishbone, has confirmed this link. This evolutionary transition occurred during the Mesozoic Era, making birds the only surviving lineage of the once-dominant dinosaur groups.

71. (D) Microfossils are recovered intact from drill rock cuttings.
Micropaleontology is essential in the petroleum industry because of the small size of the fossils. When drilling for oil, the mechanical action of the drill bit crushes large fossils into unidentifiable fragments. However, microscopic fossils like foraminifera are small enough to be recovered completely intact from the rock cuttings, allowing geologists to accurately date and correlate different layers in subsurface sections.

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54. (B) Calcite (Calcium Carbonate)
The test, or hard skeleton, of an echinoid is composed of numerous interlocking plates. These plates are made of crystalline calcite, a form of calcium carbonate. This mineralogy allows for the preservation of echinoids in the fossil record. The plates are arranged in a specific pattern that displays pentameral symmetry, which is a defining characteristic of the phylum Echinodermata.

55. (D) Echinoids
Echinoids, such as sea urchins and sand dollars, possess a skeleton called a test. This test is divided into ten alternating sectors that run from the mouth to the anus. Five of these sectors are called ambulacral areas and contain small pores for the tube feet. The other five sectors are the interambulacral areas, which are typically wider and bear the spines.

56. (A) Build massive reefs from their calcium carbonate skeletons
Corals are marine invertebrates that live either as individuals or in large colonies. They are primarily known for their ability to secrete calcium carbonate skeletons. In colonial forms, these skeletons can accumulate over long periods to build massive coral reefs. These reefs are significant geological features and support some of the most diverse and complex marine ecosystems on the planet.

57. (C) Corals
The Rugosa and Tabulata were two major orders of corals that flourished during the Palaeozoic Era. Rugose corals were often solitary and are commonly known as horn corals, while Tabulate corals were exclusively colonial. Both groups were major reef builders in ancient oceans but became completely extinct during the massive extinction event at the end of the Permian Period.

58. (A) 1 and 2 only
Trilobites and graptolites are classic examples of Palaeozoic fossils. Trilobites had durable calcite exoskeletons and complex eyes, while graptolite colonies are often preserved as carbon films that resemble pencil marks. Echinoids, however, are not exclusively Palaeozoic; while they appeared then, they diversified significantly during the Mesozoic and Cenozoic and are still common in modern oceans today.

59. (D) Brachiopods are equilateral and inequivalved, while lamellibranchs are equivalved and inequilateral.
Brachiopods and lamellibranchs are both marine invertebrates with two-valved shells, but their symmetry is fundamentally different. Brachiopod valves are of unequal size, but each individual valve is symmetrical about its midline. In contrast, lamellibranch valves are typically identical mirror images of each other but are asymmetrical individually. This distinction is a primary morphological tool used by paleontologists to identify these fossil groups.

60. (B) Brachiopods
The lophophore is a specialized, ciliated feeding organ found in brachiopods. It is typically a complex, coiled, or horseshoe-shaped structure that functions to capture food particles and facilitate gas exchange. In many brachiopod fossils, the lophophore itself is not preserved, but the delicate calcareous supports, such as brachidia, provide evidence of its presence and size within the shell cavity.

61. (C) Replacement
Replacement is a fossilization process where the original skeletal material of an organism is dissolved and simultaneously replaced by a different mineral. This occurs at the molecular level, often preserving the fine details of the original structure. Common replacement minerals include silica, pyrite, and iron oxides. This process allows for the preservation of fossils in environments where the original material would otherwise degrade.

62. (D) A fossilized worm burrow
Trace fossils, also known as ichnofossils, are geological records of the biological activity of ancient organisms rather than their physical remains. Examples include footprints, tracks, trails, and burrows. These fossils provide valuable information about the behavior, movement, and environmental interactions of organisms that may not leave behind body fossils, such as soft-bodied worms or other delicate creatures.

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hole or notch, usually found in the larger pedicle valve, through which a fleshy, muscular stalk called the pedicle is extruded. This structure allows the organism to anchor itself securely in place, helping it withstand currents while it filter feeds.

99. (C) Ammonites
Ammonites were a highly successful group of marine cephalopods that flourished throughout the Mesozoic Era. While they survived the catastrophic mass extinction at the end of the Permian Period, they were ultimately unable to survive the extinction event at the end of the Cretaceous. Their disappearance, along with that of the non-avian dinosaurs, marks one of the most significant biological turnovers in history.

100. (D) To estimate the palaeodepth of the depositional environment
The ratio of planktonic to benthic foraminifera is a fundamental tool used in micropaleontology for palaeoenvironmental analysis. In marine settings, planktonic species typically inhabit the upper water column while benthic species live on the seafloor. This numerical relationship allows geologists to estimate the water depth and the distance from the shoreline during the time the sedimentary rocks were being deposited.

101. (C) Seeds allowed plants to reproduce without dependence on water.
The evolutionary transition from spores to seeds represents a significant advancement for land plants. Unlike spores, which require an external water source to facilitate fertilization, seeds protect the embryo and provide it with nutrients. This adaptation allowed plants to colonize much drier terrestrial environments, leading to the dominance of gymnosperms and later angiosperms across various global climates and terrains.

102. (B) Group
Lithostratigraphic units are categorized based on the physical characteristics of rock layers. Within this hierarchy, a group is a high-ranking unit that consists of two or more related formations that share significant lithological features. Other terms like eon, era, and period are geochronologic units that describe intervals of time rather than the physical properties of the rocks themselves.

103. (D) South India (Dharwar Craton)
The Champion Gneiss and Peninsular Gneiss are major rock units associated with the Archaean geology of the Dharwar Craton in South India. The Peninsular Gneiss is a vast complex of granitic rocks that forms the basement of much of the southern peninsula. The Champion Gneiss is a specific, older unit often associated with the auriferous greenstone belts of the Karnataka region.

104. (A) 3, 4, 2, 1
The Cuddapah Supergroup follows a specific stratigraphic order from oldest to youngest. The sequence begins with the Papaghni Group at the base. This is followed by the Chitravati and Nallamalai Groups. The Srisailam Quartzite represents the uppermost and youngest division of the supergroup. This vertical arrangement reflects the long-term subsidence and infilling history of this Proterozoic sedimentary basin in India.

105. (C) Salt Range
The Productus Limestone is a famous fossiliferous formation of Permian age located in the Salt Range of Pakistan. It is named after the abundant brachiopod genus Productus found within its layers. This limestone provides an exceptionally rich record of marine life just before the great end-Permian mass extinction, making it a critical locality for Palaeozoic paleontological and stratigraphic research.

106. (A) Magneto-stratigraphic correlation
Magneto-stratigraphy utilizes the record of Earth's magnetic reversals preserved in sedimentary and volcanic rocks. By identifying patterns of normal and reversed polarity, geologists can correlate rock sequences between different locations. This method is independent of rock type or fossil content, making it a powerful tool for establishing a global chronological framework and understanding the timing of geological and biological events.

107. (D) South India (Cauvery Basin)
The Ariyalur and Uttatur Groups are significant stratigraphic divisions within the Cretaceous succession of the Cauvery Basin in South India. These groups record a series of marine transgressions and regressions along the eastern

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72. (A) Siliceous
Foraminifera are a diverse group of single-celled organisms that construct protective shells called tests. These tests can be made of various materials, including calcium carbonate in porcelaneous, hyaline, or microgranular forms. Agglutinated tests are made of cemented grains of sand or other debris. However, siliceous tests are not a standard primary classification for foraminifera, as silica is more typical of radiolarians or diatoms.

73. (C) An open-ocean, deep-water setting
Foraminifera are categorized based on their habitat into benthic species, which live on the seafloor, and planktonic species, which float in the water column. Planktonic foraminifera are most abundant in open-ocean environments. Therefore, a high percentage of planktonic tests in a sedimentary rock sample usually indicates that the sediments were deposited in a deep-water, offshore setting far from land.

74. (A) Fossil plants
Palaeobotany is the branch of paleontology dedicated to the study of fossilized plant remains. This field includes the analysis of diverse specimens such as impressions of leaves, petrified wood, fossilized seeds, and reproductive structures. By studying these remains, scientists can reconstruct ancient terrestrial environments, understand the evolution of plant life, and track long-term changes in Earth's climate and atmosphere.

75. (C) Statement I is true but Statement II is false.
Palynology is the specialized study of palynomorphs, which include microscopic, organic-walled structures like pollen, spores, and dinoflagellates. Contrary to having no application, palynology is extremely important in petroleum exploration. Because palynomorphs are durable and geographically widespread, they are used to date rock sequences, correlate oil-bearing strata, and evaluate the thermal maturity of organic matter in source rocks.

76. (B) Spore-bearing plants → Gymnosperms → Angiosperms
The evolution of plant life follows a clear progression through geological time. The earliest land plants were simple, spore-bearing organisms like ferns and mosses. These were followed by the emergence of gymnosperms, such as conifers and cycads, which reproduce using seeds. Finally, angiosperms, or flowering plants, appeared and rapidly became the dominant plant group during the Cretaceous and Cenozoic, shaping modern terrestrial ecosystems.

77. (C) Glossopteris
Glossopteris is the most iconic and characteristic genus of the Gondwana flora. This plant was a seed fern characterized by its tongue-shaped leaves with a distinct midrib. Its widespread distribution across India, Africa, South America, Antarctica, and Australia was a key piece of evidence used by Alfred Wegener to support his theory of continental drift and the existence of the Gondwanaland supercontinent.

78. (B) 2 and 3 only
The geological record shows that amphibians evolved and appeared before reptiles. Palynology, the study of pollen and spores, is indeed a specialized branch of micropaleontology. However, foraminifera are not exclusively Mesozoic; they first appeared in the Cambrian and have a long history that continues into the present day, with significant radiations occurring throughout the Palaeozoic, Mesozoic, and Cenozoic eras.

79. (A) Mesozoic and Cenozoic
While foraminifera first appeared during the Cambrian Period, they underwent their most dramatic diversifications during the Mesozoic and Cenozoic Eras. During these times, they evolved into a vast array of forms, including the massive radiation of planktonic species and large benthic forms like Nummulites. This high diversity and rapid evolution make them indispensable tools for modern biostratigraphy and palaeoenvironmental reconstruction.

80. (B) Extensive forests of large, spore-bearing trees like lycopods and horsetails
During the Carboniferous Period, Earth's landmasses were covered by vast, swampy forests dominated by giant spore-bearing trees like Lepidodendron and Sigillaria. These plants reached heights of over thirty meters in warm, humid conditions. When these massive forests died, the lack of decay in the swamps led to the accumulation of thick layers of organic matter,

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Craton in the south, the Singhbhum Craton in the east, and the Bundelkhand Craton in the north. The Tibetan Craton, however, is not a part of the Indian Shield; it is a separate tectonic entity located north of the Himalayan mountain range.

117. (C) Coal
The Cuddapah Supergroup is an important Proterozoic basin known for a variety of economic minerals. It contains significant deposits of barytes, asbestos, and high-quality limestone used in industry. However, it does not contain coal. In India, coal is almost exclusively found in much younger rock sequences, particularly within the Gondwana Supergroup and certain Tertiary formations in the northeastern and western regions.

118. (B) P-2, Q-1, R-4, S-3
India's geological features are distributed across the subcontinent. The Aravalli Mountain Belt is located in northwestern India. The Singhbhum Craton is a major feature of eastern India. The Cuddapah Basin is situated in the southeastern part of the peninsula. Finally, the Deccan Volcanic Province, or Deccan Traps, covers a vast area across central and western India, defining much of its landscape.

119. (D) Thrust over the younger rocks
One major theory regarding the age of the Saline Formation in the Salt Range suggests it is Eocene. In this scenario, the salt deposits were originally younger than the surrounding Cambrian rocks but were later thrust over them due to intense tectonic activity. This model explains the current structural position of the salt beds and highlight the complex deformational history of the Salt Range.

120. (B) 2 and 3 only
The Deccan Traps are primarily composed of basaltic lava, not andesitic. These massive eruptions are geologically linked to the Earth's movement over the Reunion Hotspot. A characteristic feature of the sequence is the presence of inter-trappean beds, which are sedimentary layers deposited between successive lava flows. These beds often contain fossils that provide evidence for the environment and timing of the volcanic events.

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121. (C) Gondwana Supergroup
The Barakar and Raniganj formations are the two most important coal-bearing horizons in India. They both belong to the Damuda Group of the Gondwana Supergroup. These formations consist of thick sequences of sandstones and shales with interbedded coal seams. The coal was formed from ancient forests that grew in vast river basins during the Permian Period, providing India with its primary energy resources.

122. (A) Triassic
Scleractinia is the order of modern stony corals that serve as the primary builders of coral reefs today. They first appeared in the fossil record during the Triassic Period, following the mass extinction of the Palaeozoic Rugosa and Tabulata corals. Since their emergence, scleractinian corals have evolved into a wide variety of forms and have become central components of marine biodiversity worldwide.

123. (D) Brachiopod - Echinodermata
Brachiopods are a distinct phylum of marine invertebrates characterized by two unequal valves. They are not closely related to the phylum Echinodermata, which includes organisms like starfish and sea urchins that exhibit radial symmetry. This distinction is fundamental in invertebrate paleontology, as brachiopods possess a lophophore for feeding, a feature absent in the complex water-vascular system of echinoderms.

124. (B) Ammonoids
The evolution of suture lines is a hallmark of ammonoid cephalopods. The transition from the simple, curved sutures seen in nautiloids to the zig-zag patterns of goniatitic sutures occurred in early ammonoids during the Palaeozoic. This trend toward increasing complexity continued throughout the Mesozoic, providing paleontologists with a reliable method for dating marine sedimentary rocks and tracking the evolutionary history of these organisms.

125. (C) Mammals
The Cenozoic Era is commonly referred to as the Age of Mammals. Following the mass extinction of the dinosaurs at the end of the Cretaceous, mammals underwent a rapid and extensive diversification. They evolved to fill nearly all major ecological niches on land, in the air, and in

rich Neogene vertebrate fossils. They contain remains of ancient elephants (Stegodon), giraffe-like mammals (Sivatherium), and early primates (Ramapithecus). Hence, such a fossil collection clearly indicates the Siwalik Group, making option (C) correct.

90. (A) A major bolide (asteroid/comet) impact
The K-T boundary is marked by a global enrichment of iridium, a rare element on Earth's surface but abundant in extraterrestrial bodies. This iridium anomaly provides compelling evidence for the theory that a massive bolide, such as an asteroid or comet, impacted the Earth approximately 66 million years ago. This catastrophic event is widely believed to have caused the mass extinction of dinosaurs.

91. (D) A body of rock defined on the basis of its inherent fossil content.
A biozone is the fundamental unit used in biostratigraphy. It is defined as a body of rock characterized by the presence of a specific fossil or an assemblage of fossils. Unlike lithostratigraphic units, which are based on physical rock properties, or chronostratigraphic units, which are based on time, biozones rely exclusively on the biological record preserved within the sedimentary layers.

92. (B) Sargur Group is older than the Dharwar Supergroup.
In the Archaean geology of South India, the Sargur Group is generally recognized as an older sequence than the Dharwar Supergroup. The Sargur rocks are characterized by a higher grade of metamorphism and more intense deformation compared to the typical Dharwar greenstone belts. They occur as enclaves or narrow bands within the vast Peninsular Gneiss, representing an earlier stage of crustal evolution.

93. (C) Vindhyan Supergroup
The Vindhyan Supergroup is a major Proterozoic basin in central India. Its rocks are characterized by being largely undeformed and unmetamorphosed, often remaining in their original horizontal positions. The presence of stromatolites in limestones and the occurrence of red sandstones are typical features of this sequence. These characteristics distinguish it from the older, more deformed Dharwar rocks and the younger, coal-bearing Gondwana sequences.

94. (D) Marine
Ammonites were a group of extinct cephalopods that lived exclusively in marine environments. Their presence in the Mesozoic rocks of Kutch provides definitive evidence that this region was once covered by a sea. The richness and diversity of the ammonite fauna suggest a productive marine ecosystem, allowing geologists to reconstruct the ancient geography and environmental conditions of western India during the Jurassic Period.

95. (A) Both Statement I and Statement II are true.
The Deccan Traps represent a massive volcanic event that occurred across central India during the Late Cretaceous and Early Tertiary. These basaltic flows cover a vast area. Often, sedimentary layers known as the Lameta Beds are found immediately beneath these volcanic rocks. The Lameta Beds are famous for containing terrestrial fossils, including dinosaur remains, which were preserved just before the onset of the volcanism.

96. (B) Lower and Upper Gondwana
The Gondwana Supergroup is traditionally divided into two major parts in India based on differences in lithology and fossil flora. The Lower Gondwana is characterized by the Glossopteris flora and includes major coal-bearing formations like the Barakar. The Upper Gondwana is distinguished by the Ptillophyllum flora and represents a later stage of deposition during the Triassic and Jurassic periods.

97. (C) 1 and 3 only
The oil fields of Assam are primarily found in Tertiary sandstone reservoirs, which are essential for the region's petroleum industry. Additionally, the K-T boundary is the recognized geological marker for the end of the Mesozoic Era. However, the Siwalik Group is not marine in origin; it consists of fluvial sediments deposited by rivers in the foreland basin of the rising Himalayas.

98. (A) To extrude a fleshy stalk for attachment to the substrate.
Brachiopods are marine invertebrates that typically live attached to the seafloor or other hard surfaces. The pedicle opening is a small

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which eventually became the world's major coal deposits.

81. (B) Period
The geological time scale uses two parallel sets of terminology to describe Earth's history. Geochronologic units, such as a period, refer to specific intervals of time. Chronostratigraphic units, such as a system, refer to the actual bodies of rock that were deposited during that corresponding interval. For example, the Jurassic System consists of all the rocks formed during the Jurassic Period.

82. (A) Both A and R are true and R is the correct explanation of A.
The Archaean rocks of India are predominantly composed of highly metamorphosed gneisses and schists that have undergone multiple phases of intense deformation. These extreme heat and pressure conditions are generally sufficient to destroy any delicate organic remains. Consequently, while life may have existed, recognizable fossils are exceptionally rare in these rocks, leading them to be described as largely unfossiliferous.

83. (C) Rajasthan
The Banded Gneissic Complex is a major geological terrain found in the state of Rajasthan. It represents one of the oldest crustal components of the Indian subcontinent, consisting of a complex variety of gneisses, schists, and granites. This Archaean basement served as the foundation upon which younger Proterozoic sedimentary and metamorphic sequences, such as the Aravalli and Delhi Supergroups, were subsequently deposited.

84. (B) Cuddapah Supergroup
The Cuddapah Supergroup is a significant Proterozoic sequence in South India. It is systematically divided into several major groups based on their lithological and structural characteristics. The Papaghni Group is the lowermost division, followed by the Chitravati Group. These groups contain thick successions of quartzites, shales, and limestones that record the early sedimentary history of this vast intracratonic basin.

85. (C) Siwalik Group - Marine Shale
The Siwalik Group is a sequence of sediments found in the Himalayan foothills. Unlike marine shales, it consists of fluvial deposits, including sandstones, mudstones, and conglomerates, shed from the rising mountains. In contrast, the Deccan Traps are basaltic, the Vindhyan is noted for sandstones and limestones, and the Dharwar contains ancient metamorphosed schists and gneisses, accurately representing their primary lithologies.

86. (B) Mesozoic
The Spiti Valley is renowned for its well-preserved marine stratigraphic record. While it contains Palaeozoic rocks, some of its most famous fossiliferous units, such as the Lilang Group and the Spiti Shales, belong to the Mesozoic Era. These formations provide an exceptionally detailed record of Triassic and Jurassic marine life, including diverse assemblages of ammonites that are used for international stratigraphic correlation.

87. (A) P-2, Q-4, R-1, S-3
Indian stratigraphic units are associated with distinct time intervals. The Cuddapah Supergroup is a Proterozoic sequence. The Talchir Formation represents the Early Permian glacial event. The Bagh Beds were deposited during a Cretaceous marine transgression. Finally, the Siwalik Group consists of Neogene fluvial sediments that accumulated during the Mio-Pliocene, recording the late-stage uplift of the Himalayan mountain range.

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88. (A) A widespread glaciation event
The presence of a tillite, or boulder bed, at the base of the Talchir Formation is a significant palaeoclimatic indicator. Tillites are poorly sorted sedimentary rocks formed from glacial debris. The discovery of these deposits at the start of the Gondwana sequence provides strong evidence that a major glaciation event covered much of the Indian subcontinent and other southern continents during the Early Permian.

89. (C) Siwalik Group
The fossil assemblage of Stegodon, Sivatherium, and Ramapithecus is characteristic of the Siwalik Group. These formations, found along the foothills of the Himalayas, are famous for

coast of the peninsula. They are famous for their incredibly rich and diverse marine fossils, including ammonites, which have been studied extensively for over a century.

108. (B) Lower Gondwana is dominated by Glossopteris flora, while Upper Gondwana is dominated by Ptillophyllum flora.
The division of the Gondwana Supergroup is primarily based on a significant change in the dominant fossil plant assemblages. The Lower Gondwana is characterized by the Glossopteris flora, which flourished during the Permian. In contrast, the Upper Gondwana is defined by the Ptillophyllum flora, which became dominant during the Jurassic. This floral transition reflects major changes in climate and plant evolution.

109. (A) Both Statement I and Statement II are true.
The Siwalik Group provides an exceptional and nearly continuous record of vertebrate evolution in Asia. These fluvial sediments have yielded thousands of fossils spanning from the Middle Miocene to the Early Pleistocene. This record includes a diverse array of mammals, such as ancestral elephants, horses, and various primates, offering unique insights into the development of modern mammalian lineages and their environments.

110. (D) Amber
Fossilization within amber occurs when organisms, particularly insects or small plant parts, become trapped in sticky tree resin. Over time, the resin undergoes chemical changes and hardens into a durable material, preserving the internal and external biological details with remarkable clarity. This process provides paleontologists with unique insights into the soft tissues and delicate structures of ancient life that rarely preserve.

111. (A) Trilobites
The exoskeleton of a trilobite is divided into three main body parts from front to back. The cephalon is the head shield, the thorax is the segmented middle section, and the pygidium is the posterior tail shield. The pygidium is formed by the fusion of several segments and varied greatly in size and shape among different trilobite species, aiding in their classification.

112. (B) Are adapted for a burrowing mode of life and have bilateral symmetry
Irregular echinoids, such as heart urchins, have evolved away from the perfect pentameral symmetry seen in regular sea urchins. Their tests display a clear bilateral symmetry, which is an adaptation for moving through and burrowing within soft marine sediments. This specialized mode of life has led to changes in the position of their mouth and anus, facilitating efficient feeding and waste removal.

113. (A) Both A and R are true and R is the correct explanation of A.
The suture line in ammonoids is a critical feature used for their identification and classification. These lines represent the complex junction between internal chamber walls and the outer shell. Over geological time, suture patterns evolved from simple to highly intricate forms. This rapid evolutionary change allows paleontologists to use ammonoids as precise index fossils for dating and correlating Mesozoic marine strata globally.

114. (A) Lamellibranch
The shell of a lamellibranch, or bivalve, possesses several characteristic morphological features. The umbo is the prominent, often curved beak that represents the oldest part of the shell. The pallial line is a distinct mark on the interior of the valve that indicates where the mantle was attached. These features are essential for the identification and systematic study of fossil and modern bivalves.

115. (C) Planktonic foraminifera
Globigerina and Globorotalia are well-known genera of planktonic foraminifera. These single-celled organisms live in the upper layers of the open ocean and develop intricate, multi-chambered shells made of calcium carbonate. Because they float freely, their remains are widely distributed across ocean basins after death. They are invaluable for biostratigraphy and for reconstructing past ocean temperatures and global climate changes during the Cenozoic.

116. (D) Tibetan Craton
The Indian Peninsular Shield is composed of several ancient, stable crustal blocks known as cratons. Major examples include the Dharwar

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the Proterozoic Vindhyan Supergroup. The Palaeozoic to Mesozoic Gondwana Supergroup comes next, representing continental deposition. Finally, the Cenozoic Siwalik Group is the youngest, consisting of sediments shed from the rising Himalayas. This order reflects the long-term geological evolution of the Indian subcontinent.

46. (D) Carbonization
Carbonization is a process of fossilization where the volatile components of an organism, such as oxygen and hydrogen, are driven off during burial. This leaves behind a thin, dark film of stable carbon that outlines the shape of the original structure. This method of preservation is particularly common for delicate organic remains like leaves, fish, and certain marine invertebrates like graptolites.

47. (A) Determining the absolute age of igneous rocks
Fossils are invaluable tools for correlating sedimentary rock layers, reconstructing ancient environments, and providing evidence for evolutionary changes over time. However, they cannot be used to determine the absolute age of igneous rocks, as these rocks form from cooling magma and rarely contain fossils. Absolute dating of such rocks instead requires radiometric methods based on the decay of radioactive isotopes.

48. (B) P-3, Q-4, R-1, S-2
Different fossil groups are characteristic of specific geological time intervals. Trilobites are primary Palaeozoic index fossils. Graptolites are particularly useful for dating Ordovician and Silurian strata. Ammonites were dominant marine predators during the Mesozoic Era. Nummulites, which are large foraminifera, are highly characteristic of Eocene rocks in the Cenozoic Era, often forming entire limestone beds during that time.

49. (B) A central axial lobe and two lateral pleural lobes
The name trilobite refers to the three-lobed structure of their exoskeleton. This division is longitudinal, consisting of a central axial lobe that houses the vital organs and two lateral pleural lobes that protect the limbs. While trilobites are also divided into three body parts from front to back—the cephalon, thorax, and pygidium—the three-lobed classification describes their side-to-side symmetry.

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50. (C) Statement I is true but Statement II is false.
Trilobites are an extinct group of highly diverse marine arthropods that lived throughout the Palaeozoic Era. They serve as excellent index fossils for that era because they evolved rapidly and had a wide distribution. However, they became extinct during the end-Permian mass extinction event. Therefore, they do not serve as index fossils for the subsequent Mesozoic Era.

51. (C) Ordovician and Silurian
Graptolites were colonial, planktonic hemichordates that lived in ancient oceans. They are widely recognized as some of the best index fossils for the Ordovician and Silurian periods. Their rapid evolutionary changes in morphology and their global distribution by ocean currents allow geologists to divide these periods into very fine-scale biostratigraphic zones for precise correlation of marine rock sequences.

52. (D) Graptolites
The identification and classification of graptolites rely heavily on the morphology of their colonies, known as rhabdosomes. Key features include the number of stipes, or branches, and the arrangement and shape of the individual living chambers, called thecae. These characteristics changed significantly and rapidly over geological time, making them essential tools for paleontologists studying the stratigraphy of the early Palaeozoic.

53. (A) Both A and R are true and R is the correct explanation of A.
Fossils are almost exclusively found in sedimentary rocks because these rocks form at low temperatures and pressures that favor the preservation of organic remains. In contrast, the formation of igneous rocks involves molten magma, and metamorphic rocks undergo intense heat and pressure. These extreme conditions are generally sufficient to destroy any biological material, making the presence of fossils in them rare.

the oceans, eventually leading to the emergence of modern mammalian orders, including primates and humans.

126. (D) Palynology
Palynology is a specialized field that focuses on the study of organic-walled microfossils, particularly pollen and spores. These structures are produced in vast quantities and are highly resistant to decay, allowing them to be preserved in various sedimentary environments. Palynology is a powerful tool for correlating rock layers, reconstructing ancient vegetation patterns, and interpreting past climatic conditions across geological time.

127. (A) Lithostratigraphic criteria
Lithostratigraphic classification is based entirely on the observable physical characteristics of rock layers. This includes features such as mineral composition, texture, color, and primary sedimentary structures. The goal is to divide rock sequences into recognizable units, such as formations and groups, that can be mapped in the field. This method is independent of the age or fossil content of the rocks.

128. (B) Unconformities or their correlative conformities
In sequence stratigraphy, a sequence is the fundamental unit used to analyze sedimentary successions. It is defined as a relatively conformable package of genetically related strata. Crucially, these sequences are bounded by unconformities, which represent periods of erosion or non-deposition, or by their correlative conformities in deeper parts of the basin. This framework helps geologists understand how changes in sea level shape stratigraphy.

129. (B) Archaean
The Iron Ore Group is a major geological unit found in the Singhbhum and Orissa regions of eastern India. It consists of ancient sedimentary and volcanic rocks, including prominent Banded Iron Formations. These rocks belong to the Archaean Eon and are of immense economic importance as they host some of the largest and highest-grade iron ore deposits in the entire world.

130. (A) Both Statement I and Statement II are true.
The Proterozoic history of India is dominated by the development of the Cuddapah and Vindhyan basins. The Cuddapah Supergroup is older and shows significant tectonic deformation and low-grade metamorphism in certain areas. In contrast, the Vindhyan Supergroup is younger and is known for its largely undisturbed, horizontally bedded sedimentary rocks. These differences reflect the progressive stabilization of the Indian peninsular crust.

131. (C) Ceratites
The Triassic marine sequence in the Spiti Valley is famous for its exceptionally well-preserved ammonite fauna. One of the most characteristic and abundant genera found in these strata is Ceratites. These fossils display the typical ceratitic suture pattern and are used as important index fossils for correlating Triassic rocks globally, providing evidence for the ancient Tethys Sea that once covered the region.

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132. (D) Kutch (Kachchh)
The Jurassic succession in Kutch is divided into several major stratigraphic units, including the Patcham, Chari, Katrol, and Umia series. These units represent a thick sequence of marine and near-shore sediments that were deposited as the Indian plate began to rift from Gondwanaland. They are world-renowned for their rich and diverse fossil assemblages, particularly ammonites and various marine bivalves.

133. (A) Both A and R are true and R is the correct explanation of A.
The Gondwana Supergroup is a vital component of India's geological and economic framework. It consists of thick sedimentary sequences deposited in ancient river basins. These rocks are highly significant because they host approximately 98% of the country's total coal reserves. Consequently, the Gondwana formations are the primary source of fuel for India's thermal power plants and metallurgical industries.

134. (B) Sivapithecus
The Siwalik Group is famous for its rich and diverse record of Neogene mammalian fossils. One of its most significant findings is Sivapithecus, an extinct genus of primate. These fossils are critical for understanding the evolutionary

history of hominoids in Asia. The presence of such primates, alongside ancestral elephants and horses, makes the Siwalik sequence a world-class locality for vertebrate paleontology research.

135. (D) A mould is an impression of the organism, while a cast is formed when the mould is filled with sediment.
Molds and casts are related types of fossil preservation resulting from the burial of organisms. A mold is an impression or cavity left in the surrounding sediment after the original biological material has dissolved. When this cavity is subsequently filled with minerals or other sediments, it creates a three-dimensional replica of the original organism known as a cast.

136. (A) Cephalon
The cephalon is the anterior-most body part of a trilobite, serving as its head shield. It is formed by the fusion of several segments, including those associated with the sensory organs and mouthparts. Key features of the cephalon include the central glabella and the cheeks, which often bear the complex compound eyes. This rigid structure provided essential protection for the organism's vital systems.

137. (C) Regular Echinoids
Aristotle's Lantern is a specialized and highly complex jaw apparatus found in regular echinoids, such as sea urchins. It consists of several calcareous plates and muscles that allow the organism to scrape algae and other food from rocks on the seafloor. This unique anatomical feature is named after the Greek philosopher Aristotle, who first described its lantern-like appearance in his biological writings.

138. (A) 1 and 2 only
Gastropods and cephalopods are major classes of molluscs with distinct characteristics. Gastropods are known for their coiled shells and the unique developmental process of torsion. Cephalopods, like ammonites, were active marine predators with chambered shells used for buoyancy. However, while many lamellibranchs have symmetrical valves, they are not mirror images of each other; rather, the two valves themselves are typically identical.

139. (D) Amphibians
Amphibians were the first group of vertebrates to transition from an aquatic to a terrestrial existence. They evolved from lobe-finned fish during the Devonian Period, developing limbs and lungs that allowed them to move and breathe on land. However, most early amphibians still relied on water for reproduction, representing an important intermediate stage in the colonization of land by vertebrate animals.

140. (B) For high-resolution biostratigraphic correlation of well sections.
Micropaleontology is a critical tool in petroleum exploration, primarily used for high-resolution biostratigraphic correlation. Because microfossils like foraminifera are abundant and evolve rapidly, they allow geologists to accurately date rock layers and match sequences between different drilling wells. This helps in understanding the subsurface architecture of a basin and identifying potential reservoir and source rocks for oil and gas.

141. (C) Gymnosperms (conifers, cycads) and ferns
During the Mesozoic Era, terrestrial ecosystems were dominated by non-flowering plants. The flora primarily consisted of various gymnosperms, including conifers, cycads, and ginkgos, as well as a diverse array of ferns. These plants provided the primary food source for herbivorous dinosaurs. Flowering plants, or angiosperms, did not become the dominant group until the end of the Cretaceous and the beginning of the Cenozoic.

142. (D) Geochronologic unit
Stratigraphy utilizes two parallel systems of classification. A chronostratigraphic unit, such as a system, refers to the actual body of rock that was deposited during a specific time. Its equivalent in geochronology is a geochronologic unit, such as a period, which refers solely to the interval of time itself. This distinction allows geologists to separate the rock record from the passage of time.

143. (A) The Dharwar Craton
The Closepet Granite is a prominent and extensive linear body of granitic rocks that intruded into the Archaean crust of the Dharwar Craton in South India. It stretches for hundreds of kilometers across the state of Karnataka. This

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major intrusive event occurred during the late Archaean and represents a significant period of crustal stabilization and thermal activity within the ancient southern peninsula.

144. (B) Rewa Group
The Vindhyan Supergroup is known for its diamond deposits, which are primarily associated with the Rewa Group. Diamonds in this group are found within sedimentary conglomerates, having been eroded from original volcanic sources and redeposited by ancient river systems. The Panna region is the most famous locality for these diamond-bearing rocks, which have been mined for centuries in central India.

145. (B) Spiti
A geologist seeking a complete and highly fossiliferous Palaeozoic section in the Himalayas would focus on the Spiti Valley. Known as the Tethyan Himalayan" sequence, Spiti contains a spectacular record of marine sediments spanning from the Cambrian to the Permian. These rocks are rich in diverse fossils, including trilobites and brachiopods, providing a world-class reference for Palaeozoic history in Asia.

146. (A) Nummulites
The Gondwana flora is a terrestrial plant assemblage characterized by genera like Glossopteris, Gangamopteris, and Vertebraria. These plants thrived in the ancient river valleys of Gondwanaland. Nummulites, however, are large, single-celled marine foraminifera that lived during the Cenozoic Era. They are completely unrelated to the Gondwana flora and are typically found in marine limestones deposited millions of years later.

147. (C) Lameta Formation
The Lameta Formation is an internationally significant geological unit in central India. It is famous for containing a remarkable record of Late Cretaceous terrestrial life, including skeletal remains and well-preserved nests with spherical eggs of sauropod dinosaurs. These sediments were deposited in a variety of freshwater environments just before the massive volcanic eruptions of the Deccan Traps covered the region.

148. (D) Major coal-bearing sequence
The Barail Group is a significant stratigraphic unit within the Tertiary succession of Assam. It is economically vital because it contains the region's major coal-bearing sequences. These coal seams provide an important energy resource for the northeastern states. Additionally, the Barail Group serves as a major reservoir for hydrocarbons, making it a primary target for petroleum exploration and production in India.

149. (B) 3, 2, 1
The Phanerozoic Eon is divided into three major eras that represent the history of visible life. The sequence begins with the Palaeozoic Era, characterized by early invertebrates, fish, and the colonization of land. This is followed by the Mesozoic Era, the age of dinosaurs. Finally, the Cenozoic Era began, representing the age of mammals and the development of modern ecosystems.

150. (B) They were geographically widespread and evolved rapidly.
Graptoloids were highly effective index fossils during the early Palaeozoic because of their planktonic mode of life. Being suspended in the water column allowed them to be distributed widely by ocean currents. Their rapid rate of evolutionary change in thecal structure and rhabdosome morphology enables geologists to perform high-resolution biostratigraphic correlation across different continents and various ancient marine depositional basins.

151. (D) The plane of symmetry is perpendicular to the hinge line, dividing the shell in half.
Brachiopod shells exhibit a unique form of bilateral symmetry. The plane of symmetry passes vertically through the center of both valves, perpendicular to the hinge line. This means that while the two valves themselves are of different sizes and shapes, each individual valve can be divided into two identical mirror-image halves. This characteristic distinguishes brachiopods from most other bivalved marine organisms.

152. (B) P-4, Q-3, R-1, S-2
Different fossil groups possess unique morphological features. A siphuncle is a characteristic buoyancy tube in cephalopods. The lophophore is a specialized feeding organ in

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presence in Kutch has allowed geologists to create a highly detailed biostratigraphic framework for the Mesozoic Era in western India and beyond.

189. (C) Position of the anus and peristome
Regular and irregular echinoids are distinguished by the arrangement of their primary anatomical openings. Regular echinoids have a mouth on the oral surface and an anus at the center of the aboral surface. In irregular echinoids, which are adapted for burrowing, the anus and sometimes the mouth have shifted to different positions, resulting in a bilateral symmetry rather than radial.

190. (D) Brachiopoda
The phylum Mollusca is a highly diverse group of invertebrates that includes classes such as Gastropoda, Cephalopoda, and Lamellibranchia. While brachiopods superficially resemble bivalve molluscs because they have two shells, they belong to an entirely separate phylum. Brachiopods have a different internal anatomy, including a lophophore for feeding, and their shells exhibit a different type of symmetry compared to molluscs.

191. (A) Theropod dinosaurs
The fossil record provides compelling evidence that modern birds evolved from a specific group of small, feathered theropod dinosaurs. Key transitional fossils, such as Archaeopteryx, demonstrate a mix of reptilian features, including teeth and a long tail, alongside avian characteristics like feathers and wings. This evolutionary lineage highlights the profound biological connection between avian species and their dinosaurian ancestors during the Mesozoic.

192. (B) Dominance of the tongue-shaped leaf 'Glossopteris'
The most significant characteristic of the Gondwana flora is the overwhelming dominance of the plant genus Glossopteris. This plant, a seed fern with distinctive tongue-shaped leaves, was the primary component of the vast Permian forests of the southern hemisphere. Its fossilized remains are essential for identifying Gondwana strata and were crucial in developing the theory of continental drift and plate tectonics.

193. (B) Faunal succession
The principle of faunal succession is a foundational concept in stratigraphy. It states that fossils appear and disappear in the rock record in a predictable and determinable order. Because of this, any specific time period can be recognized by its unique fossil content. This principle allows geologists to correlate rock layers over vast distances and is the basis for the biostratigraphic time scale.

194. (A) Supergroup
In the hierarchy of lithostratigraphic units, the supergroup is the highest-ranking division. It consists of two or more related groups that share significant geological characteristics. Below the supergroup are groups, which are then further divided into formations, members, and beds. This systematic classification allows geologists to organize and describe rock sequences at various scales, from entire basins to individual layers.

195. (C) 1 and 3 only
The Dharwar Supergroup is economically vital, hosting major gold deposits like those in the Kolar Gold Fields. Similarly, the Cuddapah Supergroup is known for its significant reserves of industrial minerals like barytes. However, the Vindhyan Supergroup is not a major source of coal; in India, coal is primarily found in the Gondwana sequence and certain Tertiary formations in the north and west.

196. (D) Sediments deposited in the ancient Tethys Sea
The term Tethyan refers to the ancient Tethys Sea, which once existed between the northern supercontinent of Laurasia and the southern supercontinent of Gondwanaland. The Tethyan Himalayan sequence, found in regions like Spiti and Kashmir, consists of thick marine sediments that were deposited on the northern shelf of the Indian plate. These rocks were later uplifted during the formation of the Himalayas.

197. (C) Cretaceous
The Trichinopoly Group is a major stratigraphic unit within the Cretaceous succession of the Cauvery Basin in South India. It is internationally recognized for its exceptionally rich and diverse assemblage of marine fossils, including ammonites, nautiloids, and various bivalves.

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directly into a gas without becoming a liquid. It is not a mechanism for the preservation of fossils in the rock record.

162. (A) Both A and R are true and R is the correct explanation of A.
Graptolites are considered ideal index fossils for the Ordovician and Silurian periods. Their success in biostratigraphy is due to their planktonic mode of life, which allowed for rapid global dispersal by ocean currents. Furthermore, they underwent quick morphological evolution, enabling geologists to establish a high-resolution chronological framework for correlating marine rock sequences across different continents and deep-sea basins.

163. (C) The nature of the suture line and the position of the siphuncle.
The classification of cephalopods into nautiloids and ammonoids is primarily based on their internal shell structures. Nautiloids are characterized by simple, curved suture lines and a centrally located siphuncle. Ammonoids evolved increasingly complex, folded suture patterns and typically possessed a siphuncle located along the outer edge, or venter, of the shell. These features are critical for their systematic study and biostratigraphic use.

164. (D) Tertiary
The major oil and gas reserves in Assam are hosted within rock formations of the Tertiary Period. Significant production comes from the sandstones of the Tipam and Barail groups. These sediments were deposited in a variety of marine and fluvial environments as the Indian plate collided with Eurasia. The Tertiary sequence in Assam remains one of India's most important petroleum provinces.

165. (C) Changes in sea level
Sequence stratigraphy is a modern geological framework that analyzes sedimentary rock successions in the context of fluctuating sea levels. By integrating seismic, well-log, and outcrop data, geologists can identify packages of strata that were deposited during specific cycles of sea-level rise and fall. This approach is powerful for predicting the distribution of reservoir and source rocks within a sedimentary basin.

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166. (B) Dharwar Supergroup - Gold (Kolar)
The Dharwar Supergroup is economically famous for its gold deposits, particularly in the Kolar Gold Fields of Karnataka. In contrast, the Vindhyan Supergroup is known for building stones and diamonds, not coal. The Gondwana Supergroup is the primary source of Indian coal, while the Deccan Traps are composed of volcanic basalt flows and do not typically contain significant marine fossils.

167. (D) A layered sedimentary structure created by cyanobacteria
Stromatolites are distinctive, layered sedimentary structures primarily formed by the growth and activity of microbial mats, especially cyanobacteria. These organisms trap and bind sediment or precipitate calcium carbonate, creating alternating layers over time. They are among the oldest evidences of life on Earth, providing crucial information about the environmental and biological conditions of the Archaean and Proterozoic eons.

168. (A) Cretaceous
The Bagh Beds are a series of marine sedimentary rocks of Cretaceous age found in the Narmada Valley of central India. They represent a significant marine transgression into the interior of the Indian Peninsula. These beds are famous for their rich fossil content, including echinoids, brachiopods, and ammonites, which provide evidence for the marine environments and sea-level changes of that time.

169. (A) 1 and 2 only
The Gondwana Supergroup consists primarily of fluvial and lacustrine sediments deposited in vast river basins and lakes. The sequence characteristically begins with the Talchir Formation, which provides evidence of a widespread Permian glaciation through its distinctive boulder beds. However, the flora of the Gondwana period was dominated by gymnosperms and ferns like Glossopteris, not by flowering plants or angiosperms.

170. (A) One valve (brachial) contains the lophophore supports, the other (pedicle) has the pedicle opening.
Brachiopods are marine invertebrates with two unequal valves that are distinguished by their

brachiopods. A pygidium represents the posterior tail shield of a trilobite. Finally, ambulacral areas are the specialized sectors on an echinoid test that contain the pores for tube feet, highlighting the diversity of invertebrate anatomy.

153. (C) Gastropods
Dextral and sinistral are terms used in malacology to describe the direction of coiling in gastropod shells. A dextral shell coils in a clockwise direction, with the aperture typically appearing on the right side when the apex is held upward. A sinistral shell coils counter-clockwise, with the aperture on the left. This coiling direction is a genetically determined trait used in species identification.

154. (A) Cretaceous Period
The appearance and rapid diversification of angiosperms, or flowering plants, was one of the most significant events in the history of life on Earth. This evolutionary radiation began during the Cretaceous Period. Angiosperms developed complex reproductive structures and co-evolved with insects for pollination, eventually leading to their dominance in nearly all terrestrial habitats by the beginning of the Cenozoic Era.

155. (D) The first appearance, last appearance, or range of one or more fossil taxa
The boundaries of a biostratigraphic zone are defined by significant biological events recorded in the rock strata. These include the first appearance of a new species or the final extinction of an existing one. By tracking the vertical range of specific fossils, geologists can divide sedimentary sequences into distinct zones that facilitate precise temporal correlation between different geographic locations worldwide.

156. (B) Iron, manganese, and chromite
The Archaean rocks of Jharkhand and Orissa are renowned for their incredible mineral wealth. This region hosts some of the world's largest deposits of high-grade iron ore within the Banded Iron Formations. Additionally, it contains significant reserves of manganese and chromite. These metallic minerals are essential for the metallurgical industry, making this area a vital economic hub for India's mineral production.

157. (C) Statement I is true but Statement II is false.
The Cuddapah Supergroup is a major Proterozoic sedimentary basin located along the eastern margin of the Indian Peninsula. While it is true that some areas along the eastern boundary show significant folding and deformation, much of the western part of the basin contains relatively unmetamorphosed and gently dipping rock layers. This variation reflects the complex tectonic history of the basin's development.

158. (D) The Spiti Valley
The Haimanta and Kanawar Groups are important Palaeozoic stratigraphic units found in the Spiti Valley of the Himalayas. The Haimanta Group represents a thick sequence of Cambrian sediments, while the Kanawar Group includes carboniferous strata such as the Lipak and Po Formations. These units provide a detailed record of the marine environments that existed along the northern margin of Gondwanaland.

159. (A) Marine transgressive sequence
The Cretaceous succession in the Trichinopoly area of South India is a classic example of a marine transgressive sequence. During this period, rising global sea levels caused the ocean to flood onto the eastern margin of the Indian Peninsula. This resulted in the deposition of a thick series of fossiliferous marine sediments, including the Uttatur, Trichinopoly, and Ariyalur groups.

160. (B) Barakar and Raniganj
The Damuda Group is the most significant coal-bearing division within the Gondwana Supergroup of India. It includes two major formations that contain vast coal reserves: the Barakar Formation and the Raniganj Formation. These coal seams were formed from ancient, lush forests in river basins and provide the primary source of fuel for the country's energy and iron and steel industries.

161. (B) Sublimation
Fossilization involves several geological processes that preserve organic remains over time. Permineralization fills pores with minerals, carbonization leaves a carbon film, and replacement substitutes biological material with minerals at a molecular level. Sublimation, however, is a physical process where a solid turns

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The resulting cast preserves the external shape and size of the original organism with great detail.

180. (B) P-3, Q-1, R-4, S-2
Palaeontological terms describe specific anatomical features across different fossil groups. A test is the protective shell of an echinoid or foraminifer. A rhabdosome refers to the entire colony of a graptolite. Suture lines are the complex junctions between internal walls and the shell in ammonites. Torsion is the unique twisting of the visceral mass that occurs during the development of gastropods.

181. (C) Permian-Triassic
The evolutionary transition from synapsid reptiles, also known as mammal-like reptiles, to the first true mammals was a major biological event. This transition occurred over a long period but reached a critical stage during the Late Permian and Early Triassic. This lineage survived the massive end-Permian extinction and eventually led to the emergence of diverse mammalian groups that became dominant during the Cenozoic Era.

182. (B) Indicating palaeoclimatic and palaeoceanographic conditions
Beyond biostratigraphy, foraminifera are vital tools for reconstructing ancient environments. The isotopic composition and chemical makeup of their calcite tests reflect the temperature, salinity, and chemistry of the seawater in which they lived. By analyzing fossilized foraminifera, scientists can track long-term changes in global climate and ocean circulation, which is essential for understanding Earth's complex environmental history and future trends.

183. (D) Gondwana Flora
The combination of Glossopteris, Gangamopteris, and Noeggerathiopsis is the defining characteristic of the Gondwana flora. These plants were dominant in the southern continents, including India, during the Permian and Triassic periods. Their widespread presence provided strong evidence for the existence of the ancient supercontinent Gondwanaland. This flora is also the primary source of the vast coal deposits found in India.

184. (A) The law of superposition and fossil succession
The Geological Time Scale is a fundamental framework built upon basic stratigraphic principles. The law of superposition states that younger rocks are deposited on top of older ones. The principle of faunal succession recognizes that fossils follow each other in a predictable order. Together, these rules allow geologists to organize the Earth's history into a chronological sequence of eras, periods, and epochs.

185. (A) Both Statement I and Statement II are true.
The Indian Peninsula is built upon a foundation of ancient Archaean rocks, which form the stable basement of the subcontinent. These rocks include various gneisses and schists that have undergone multiple phases of deformation. The Dharwar Supergroup is a classic example of these Archaean sequences, providing critical evidence for the early tectonic and crustal evolution of the southern part of India.

186. (A) Vindhyan Supergroup
The Vindhyan Supergroup is a major source of high-quality building materials in India. It contains extensive beds of durable sandstone, often called Vindhyan Sandstone, which have been used for centuries to construct historic monuments like the Sanchi Stupa and the Red Fort. Additionally, the supergroup provides large quantities of limestone and other stones essential for modern construction and industry.

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187. (A) Both A and R are true and R is the correct explanation of A.
The Salt Range in Pakistan is geologically significant due to its remarkably condensed and structurally complex stratigraphic succession. It exposes a nearly continuous record of rocks from the Precambrian to the Tertiary within a small area. This proximity is caused by major tectonic thrusts and faults that have brought different-aged formations into direct contact, providing a unique window into regional geology.

188. (B) Ammonites
The Jurassic succession in the Kutch region is world-renowned for its exceptionally well-preserved ammonite fauna. These extinct marine cephalopods are found in great abundance and diversity within the sedimentary layers. Ammonites are excellent index fossils, and their

It must have a short geological range, meaning the species existed for only a brief period, allowing for precise dating. Finally, it should be geographically widespread, enabling geologists to correlate rock layers across different regions and diverse ancient ocean basins.

207. (A) Late Devonian
Gymnosperms, which are non-flowering plants that reproduce using seeds, first appeared in the fossil record during the Late Devonian Period. These early seed plants evolved from spore-bearing ancestors and represent a major advance in plant evolution. By developing seeds, they were able to colonize a wider range of terrestrial environments, eventually becoming the dominant land flora throughout much of the Mesozoic Era.

208. (A) Both Statement I and Statement II are true.
Lithostratigraphic units are defined by their physical characteristics, such as lithology and texture, rather than their age. Because these units represent specific depositional environments, their boundaries can be diachronous. This means that a single rock unit, like a sandstone formation, can be deposited at different times in different locations as environmental conditions shift, thereby cutting across lines of geological time.

209. (B) Khondalites
The Eastern Ghats Mobile Belt is a high-grade metamorphic terrain characterized by distinctive rock types. Alongside charnockites, it is well known for khondalites, which are garnet-sillimanite-graphite schists. These rocks represent ancient sedimentary sequences that were subjected to intense temperature and pressure during Proterozoic tectonic events. The Eastern Ghats provide essential insights into the deep-crustal processes that shaped the eastern margin of the Indian Peninsula.

210. (A) It contains rich deposits of metallurgical coal.
The Vindhyan Supergroup is a significant Proterozoic sequence in central India, known for its horizontally bedded sedimentary rocks and high-quality building stones and limestone. However, it does not contain metallurgical coal. In India, significant coal deposits are almost entirely restricted to the much younger Gondwana Supergroup and certain Tertiary formations. The Vindhyan rocks were deposited long before the evolution of large coal-forming plants.

211. (C) Kashmir and Spiti
The Po Series and Fenestella Shales are important Palaeozoic stratigraphic units found in the Tethyan Himalayan sequence of Kashmir and Spiti. The Fenestella Shales are named after a characteristic genus of bryozoan and are typically of Carboniferous age. These formations provide a rich record of marine life and environmental conditions along the northern margin of Gondwanaland during the latter half of the Palaeozoic Era.

212. (D) Mesozoic
The presence of ammonites and belemnites, both extinct groups of cephalopods, along with various oysters, is strongly indicative of a Mesozoic age. Ammonites and belemnites were dominant in marine environments throughout the Triassic, Jurassic, and Cretaceous periods before becoming extinct. Finding these fossils together allows geologists to confidently assign the rock layers to the Mesozoic Era, representing an ancient sea that once covered the area.

213. (A) Both A and R are true and R is the correct explanation of A.
The Siwalik Group is a classic example of a molasses deposit, consisting of thick sequences of sandstones and mudstones. These sediments were derived from the rapid erosion of the rising Himalayan mountain range. As the mountains were uplifted by tectonic forces, huge volumes of sediment were transported and deposited by rivers into the adjacent foreland basin, creating the thick Siwalik sequence.

214. (B) Paleogene Period
The K-T Boundary, now more formally called the Cretaceous-Paleogene or K-Pg boundary, marks the end of the Cretaceous Period and the start of the Paleogene Period. This boundary is associated with a massive extinction event that occurred approximately 66 million years ago. It represents a fundamental transition in Earth's history, as it saw the end of the dinosaur age and the beginning of the mammal age.

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These fossils provide a detailed record of marine ecosystems and sea-level changes during the Late Cretaceous along the eastern margin of India.

198. (B) Lithology and floral content
The classification of the Gondwana Supergroup in India is primarily based on its physical rock characteristics and its unique fossil plant assemblages. The sequence is divided into groups and formations that reflect different depositional environments, from glacial to fluvial and lacustrine. Additionally, the transition from the Glossopteris flora to the Ptillophyllum flora provides a fundamental biostratigraphic basis for dividing the supergroup.

199. (D) Tipam Sandstone (Tertiary)
The Digboi oil field in Assam is historically significant as the oldest producing oil field in India. The petroleum is extracted from Tertiary rock formations, specifically within the Tipam Sandstone. This geological unit consists of fluvial and deltaic sediments that provide excellent reservoir properties. The presence of oil in these Tertiary strata has been the foundation of the petroleum industry in northeastern India for over a century.

200. (A) Permineralization.
Permineralization is a common fossilization process where mineral-rich groundwater flows through the pores and cavities of buried bones, shells, or wood. Minerals such as silica or calcite precipitate from the water and fill these spaces, eventually hardening the remains into rock. This process often preserves the internal cellular structure of the organism, providing detailed information for paleontological study and analysis over geological time.

201. (C) Pleural lobe
The cephalon of a trilobite includes various parts such as the central glabella and the cheeks, known as librigena and fixigena. However, the pleural lobes are not part of the cephalon. Instead, they are the lateral sections of the thorax and pygidium that run alongside the central axial lobe. This three-lobed longitudinal division is the fundamental anatomical characteristic from which the name trilobite is derived.

202. (A) Graptolites
The identification and classification of graptolites depend on the morphology of their colonies. Key features include the internal structure of the individual thecae, the total number of branches or stipes, and the overall shape and growth form of the complete colony, known as the rhabdosome. These characteristics changed rapidly over time, making graptolites exceptional tools for biostratigraphic correlation during the Ordovician and Silurian.

203. (D) Skeletal mineralogy from calcite to aragonite
A major evolutionary transition in corals occurred between the Palaeozoic and the Mesozoic eras. The Palaeozoic Tabulata and Rugosa corals constructed their skeletons primarily from calcite. In contrast, the Scleractinia corals, which appeared in the Triassic and dominate modern reefs, secrete skeletons made of aragonite. This change in skeletal mineralogy represents a significant physiological and biochemical shift in the history of coral evolution.

204. (B) A chambered shell with a siphuncle
The most distinctive morphological feature that separates cephalopods from other molluscs is their chambered shell. The shell is divided into compartments by walls called septa, and these chambers are connected by a tube known as the siphuncle. This specialized apparatus allows cephalopods to adjust gas and fluid levels within the shell to regulate their buoyancy and move efficiently through the ocean water column.

205. (C) Devonian
The Devonian Period is famously known as the Age of Fishes because it witnessed an incredible radiation and diversification of aquatic vertebrates. During this time, all major groups of fish, including jawless fish, placoderms, cartilaginous fish, and lobe-finned fish, were present and dominated the oceans. This period also saw the emergence of the first amphibians, marking the beginning of the vertebrate transition to land.

206. (D) Abundant, short-ranging, and geographically widespread.
An ideal index microfossil for biostratigraphy must meet several specific criteria. It should be abundant and easy to find in sedimentary rocks.

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internal and external anatomy. The pedicle valve is typically larger and contains an opening for the attachment stalk. The brachial valve is smaller and houses the specialized calcareous supports, such as brachidia, for the filter-feeding lophophore. These morphological differences are essential for the systematic identification of fossil brachiopods.

171. (D) Cretaceous-Paleogene (K-Pg) extinction
The mass extinction event at the end of the Cretaceous Period is now officially known as the Cretaceous-Paleogene, or K-Pg, extinction. This global catastrophe resulted in the disappearance of approximately 75% of all species on Earth, including the non-avian dinosaurs and marine groups like ammonites. It marks a major biological turning point that allowed for the subsequent rise and diversification of mammals.

172. (B) Eocene (Tertiary)
Nummulites are a genus of large, coin-shaped benthic foraminifera that lived in shallow, warm marine environments. They were so abundant during the Eocene Epoch that their remains often form thick beds of limestone, such as those used to build the Egyptian pyramids. Finding Nummulites fossils is a definitive indicator that the host rock belongs to the early Tertiary Period.

173. (C) The Palaeozoic and Mesozoic
The stratigraphic succession in the Spiti Valley is geologically significant because it provides an exceptionally complete and well-preserved record of marine life and environments across both the Palaeozoic and Mesozoic eras. Spanning from the Cambrian to the Cretaceous, this sequence is a world-class locality for studying the evolution of marine ecosystems along the northern margin of the Indian subcontinent.

174. (D) Northwestern India (Rajasthan)
The Delhi and Aravalli Supergroups are major Precambrian geological units located in northwestern India, primarily within the state of Rajasthan. The Aravalli Supergroup represents an older Proterozoic sequence, while the Delhi Supergroup is younger. Together, they form the structural backbone of the Aravalli Mountain Range, which is one of the oldest mountain belts in the world, providing insights into early tectonics.

175. (A) Vindhyan Supergroup
The Semri Group is the lowermost and oldest subdivision of the Vindhyan Supergroup in central India. It consists of a thick sequence of sandstones, shales, and limestones that record the initial stages of sedimentation within the Vindhyan basin. This group is also known for its stromatolites and volcanic rocks, which provide important data on the Proterozoic environments of the Indian Peninsula.

176. (B) The lava is predominantly rhyolitic in composition.
The Deccan Traps are one of the world's largest volcanic provinces, but they are composed predominantly of basaltic lava, not rhyolitic. These massive eruptions occurred at the end of the Cretaceous Period and are characterized by thick, horizontal flows. Between these volcanic layers, sedimentary inter-trappean beds often contain fossils, providing a record of the biological life that existed during this intense volcanic era.

177. (B) Lower Gondwana Group
A rock sequence containing the Talchir Tillite at the base, followed by the Barakar and Raniganj Formations, is characteristic of the Lower Gondwana Group. This succession records a major climatic shift from glacial conditions in the Early Permian to warm, humid environments that supported vast forests. These forests eventually formed India's most significant coal reserves, which are economically vital today.

178. (A) Cenozoic mammals
The Siwalik Hills are globally famous for their incredibly rich and diverse record of Cenozoic mammalian fossils. These sediments have yielded thousands of specimens, including ancestral elephants, horses, giraffes, and various primates. This fossil record is one of the most complete in the world for the Neogene Period, offering unique insights into the evolution and diversification of mammals in the Asian continent.

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179. (C) Cast
A cast is a three-dimensional fossil formed when a natural mold, or impression, of an organism is filled with sediment or minerals. After the original biological material has dissolved or decayed, the empty space is filled by percolating water or sediment, which then hardens into rock.

215. (D) Carbonization
Carbonization is a process of fossilization where the organic components of an organism are chemically altered during burial. Volatile substances like hydrogen and oxygen are driven off, leaving behind a stable, thin film of carbon. This process often perfectly preserves the outline and surface details of delicate structures such as leaves or fish. These dark carbon films are commonly found on the bedding planes of fine-grained sedimentary rocks.

216. (A) Scleractinian corals
Scleractinian corals are not an extinct group; they are the modern stony corals that build reefs in oceans today. They first appeared in the Triassic Period and survived several major extinctions. In contrast, trilobites, graptolites, and rugose corals were all significant groups of invertebrates that existed during the Palaeozoic Era but have since become completely extinct, leaving behind only their fossilized remains in the rock record.

217. (B) P-4, Q-3, R-1, S-2
Different fossil genera belong to specific biological groups used for biostratigraphy. Perisphinctes is a common Mesozoic ammonite. Productus is a characteristic Palaeozoic brachiopod. Paradoxides is a well-known genus of Cambrian trilobite. Monograptus is an important Silurian graptolite. These genera are essential for dating rock layers and reconstructing the evolutionary history of marine life across various periods and eras of the geological time scale.

218. (A) Lungs and limbs capable of supporting the body on land.
The evolutionary transition from fish to amphibians was a milestone in vertebrate history. This process involved the development of lungs for breathing air and strong limbs with digits to support the body's weight on land. These adaptations allowed early amphibians to explore terrestrial environments while still maintaining a link to aquatic habitats for reproduction. This transition paved the way for the subsequent diversification of all land-dwelling vertebrates.

219. (D) Planktonic and Benthic
Foraminifera are categorized into two primary groups based on their mode of life. Planktonic foraminifera float in the upper layers of the ocean and are widely dispersed by currents. Benthic foraminifera live on or within the seafloor sediments. Both groups produce characteristic tests, and their relative abundance is used by geologists to determine past water depths, ocean temperatures, and other important environmental conditions during sediment deposition.

220. (B) Uniformitarianism
Uniformitarianism is a cornerstone of modern geology, suggesting that the physical and chemical processes observed today have operated throughout Earth's long history. By studying current geological events, such as erosion and volcanic activity, scientists can interpret the ancient features preserved in the rock record. This principle allows for the reconstruction of past environments based on the continuity of natural laws across geological time.

221. (C) Indo-Gangetic Plains
The Indian subcontinent is geologically divided into three major tectonic units. The Peninsular Shield is the ancient, stable basement. The Himalayas are a young, active mountain belt formed by continental collision. Between these two lies the Indo-Gangetic Plains, a vast foreland basin filled with thick deposits of recent alluvium. Together, these regions define the primary structural and physiographic framework of the entire Indian landmass.

222. (D) Granulite-gneiss terrains
The Archaean basement of South India is primarily composed of two distinct geological terrains. Greenstone belts consist of metamorphosed volcanic and sedimentary rocks. Surrounding these are vast granulite-gneiss terrains, which include high-grade metamorphic rocks like charnockites and the extensive Peninsular Gneiss complex. These terrains record the early stages of crustal growth, deformation, and thermal events that occurred billions of years ago on the Indian shield.

223. (A) Proterozoic intracratonic basin
The Cuddapah basin is a classic example of an intracratonic basin that developed during the Proterozoic Eon. It formed on the stable Archaean crust of the Indian Peninsula and accumulated thick sequences of relatively undeformed sedimentary and volcanic rocks. This basin

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240. (B) Both A and R are true but R is not the correct explanation of A.
Cephalopod suture lines represent the junction where internal septa meet the outer shell wall. In nautiloids, these sutures are simple and curved. In contrast, ammonoids evolved complex, folded suture patterns through time. These folds increased the structural strength of the shell against water pressure and provided more surface area for the attachment of the organism's muscular tissues, reflecting a significant evolutionary advancement in their functional morphology.

241. (B) Agglutinated
Agglutinated foraminifera are a group of single-celled organisms that construct their tests by cementing together foreign particles from their environment. These particles can include sand grains, mica flakes, or even the remains of other small fossils. This construction method distinguishes them from other foraminifera that secrete their own tests from calcium carbonate. Agglutinated forms are often very durable and are commonly found in a variety of marine settings.

242. (A) Stratigraphy
The Law of Superposition is a fundamental principle of stratigraphy. It states that in an undisturbed sequence of sedimentary rocks, each layer is older than the one above it and younger than the one below it. This concept allows geologists to establish a relative chronological order for rock strata. It is the essential foundation for building the geological time scale and understanding the sequence of events in Earth's history.

243. (C) Petroleum
The Dharwar Supergroup in Karnataka is a major source of metallic minerals. It hosts the world-famous Kolar Gold Fields and contains vast deposits of high-grade iron and manganese ore within its greenstone belts. However, it does not contain petroleum. Petroleum is typically found in much younger sedimentary basins, whereas the Dharwar rocks are ancient, highly metamorphosed Archaean sequences that formed long before the accumulation of oil-producing organic matter.

244. (D) Semri Group of the Vindhyan Supergroup
The Semri Group represents the lowermost division of the Vindhyan Supergroup in central India. It is characterized by a specific sequence of rock layers, including basal sandstones, stromatolitic limestones, and the prominent Rohtas Limestone at its top. These sediments record the early Proterozoic marine environments of the Vindhyan basin. The presence of glauconitic sandstones and purple shales further serves as a diagnostic feature for identifying this stratigraphic group.

245. (C) Permian
The Zewan beds of Kashmir are a significant stratigraphic unit of Permian age. They are famous for their rich and diverse marine fossil fauna, which includes numerous brachiopods and various other invertebrates. These beds record the environmental conditions and biological life that existed in the Tethyan region just before the major extinction event at the end of the Palaeozoic Era, making them important for regional stratigraphic correlation.

246. (A) 2, 4, 1, 3
The history of life follows a clear chronological sequence. Trilobites first appeared in the early Cambrian. Land plants began to colonize the Earth during the Silurian and Devonian periods. The mass extinction of the non-avian dinosaurs occurred at the end of the Cretaceous, approximately 66 million years ago. Finally, the first early human ancestors appeared much more recently, during the late Cenozoic. This progression reflects Earth's biological evolution.

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247. (D) Upper Gondwana (Jurassic)
The Ptillophyllum flora is the characteristic plant assemblage found in the Upper Gondwana sequence of India. This flora became dominant during the Jurassic Period, following the decline of the earlier Glossopteris flora. It is characterized by various gymnosperms, particularly cycads and conifers. The transition from Glossopteris to Ptillophyllum represents a major shift in climate and plant evolution during the long history of Gondwanaland's sedimentary deposition.

248. (A) Palaeozoic
Graptolites are a group of colonial, planktonic organisms that are exclusively found in rocks

232. (A) Era
In the terminology of geological time, an era is a major geochronologic unit that represents a specific span of time, such as the Mesozoic or Palaeozoic. Other terms like system, series, and stage are chronostratigraphic units, which refer to the actual bodies of rock deposited during those corresponding time intervals. Geochronologic units help geologists organize history, while chronostratigraphic units focus on the physical rock record.

233. (C) Singhbhum Craton
The Dalma lavas are a prominent volcanic sequence found within the Singhbhum Craton of eastern India. These rocks represent ancient submarine volcanic activity that occurred during the Proterozoic. They form a distinct arcuate belt and provide important evidence for the tectonic and magmatic processes that shaped the eastern part of the Indian Shield. The Dalma lavas are often associated with complex sedimentary and metamorphic rock successions.

234. (A) Age and structural position
The Saline Formation of the Salt Range has been a source of significant geological debate. Its uncertain age stems from conflicting evidence; it appears below Cambrian rocks but some geologists suggest an Eocene age due to possible thrusting. This controversy over its structural position and timing of deposition highlight the complex tectonic history of the region and the challenges in interpreting highly deformed sedimentary sequences.

235. (D) Abundant, well-preserved ammonites in nodules
The Spiti Shales are a famous Jurassic formation in the Tethyan Himalayan region. They are highly renowned among paleontologists for containing an abundance of well-preserved ammonites, which are often found encased within hard calcareous nodules. These fossils provide an exceptionally detailed record of marine life in the Tethys Sea during the Late Jurassic and are used for global stratigraphic correlation and understanding cephalopod evolution.

236. (B) The sedimentary layers between basalt flows of the Deccan Traps
Inter-trappean beds are sedimentary layers that occur between successive volcanic flows of the Deccan Traps. These beds were deposited in lakes and rivers during periods of volcanic quiescence. They are paleontologically significant because they often contain fossils of plants, invertebrates, and even small vertebrates. These fossils provide a unique record of the terrestrial and freshwater environments that existed between major episodes of basaltic lava eruptions.

237. (C) Hydrocarbons
The Surma Valley in Northeast India contains a thick and extensive sequence of Tertiary sedimentary rocks. These strata are geologically significant because they host major reserves of hydrocarbons, including both oil and natural gas. The sandstones within the Surma and Tipam groups serve as primary reservoirs. Consequently, this region is one of the most important petroleum provinces in India, supporting long-term energy exploration and production.

238. (D) Body fossils are remains of the organism itself, while trace fossils are records of its activity.
Paleontology distinguishes between two primary types of fossils. Body fossils consist of the actual physical remains of an organism, such as bones, teeth, or shells. In contrast, trace fossils, or ichnofossils, provide evidence of the behavior or movement of an organism, such as footprints, burrows, or feeding marks. Together, they provide a more complete understanding of ancient life and how organisms interacted with their environments.

239. (A) Septa
The skeleton of a coral polyp is characterized by internal radial plates called septa. These structures grow from the outer wall of the coral toward the center, dividing the body cavity. The number and arrangement of septa are critical features used by paleontologists to identify and classify different coral groups. In rugose corals, septa were added in a specific four-fold pattern, which is a hallmark of their Palaeozoic order.

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273. (B) Aperture
The shell of a gastropod, or snail, grows through the addition of new layers of calcium carbonate at the aperture, which is the shell's opening. As the organism matures, it progressively adds material along this edge, causing the shell to expand and often coil around a central axis. The oldest part of the shell is the apex, while the most recently formed material is located at the apertural margin.

274. (A) Past sea-surface temperatures
Foraminifera are powerful tools for reconstructing past climates. As they build their calcite tests, they incorporate oxygen isotopes from the surrounding seawater. The ratio of oxygen-18 to oxygen-16 in these fossilized tests is directly influenced by the temperature of the water at that time. By analyzing this isotopic signal, scientists can accurately infer past sea-surface temperatures, providing critical data for understanding global climate changes throughout geological history.

275. (C) Tectonic styles and crustal evolution
The division of the Precambrian into the Archaean and Proterozoic eons is based on major shifts in the Earth's tectonic behavior and crustal growth. The Archaean was characterized by more intense heat flow and the formation of the first cratonic nuclei. In contrast, the Proterozoic saw the development of large, stable continents, modern-style plate tectonics, and the formation of extensive sedimentary basins. These changes reflect the long-term cooling and stabilization of the planet.

276. (D) Vindhyan Supergroup
The Bhander Group is the uppermost and youngest major division of the Vindhyan Supergroup in central India. It consists of a thick sequence of sandstones, shales, and limestones that record the final stages of sedimentation in this vast Proterozoic basin. The Bhander rocks are well known for their high-quality building stones and for preserving various sedimentary structures that provide insights into the ancient shallow marine and coastal environments.

277. (C) Limestones, shales, and dolomites
The Triassic rocks of the Spiti Valley are primarily composed of a thick marine sequence known as the Lilang Group. This succession is lithologically dominated by various limestones, shales, and dolomites. These sediments were deposited in a productive marine environment on the northern shelf of Gondwanaland. The abundance of these carbonate and fine-grained rocks has facilitated the excellent preservation of diverse marine fossils, particularly ammonites.

278. (B) Upper Gondwana
The Jabalpur and Kota Formations are significant stratigraphic units within the Upper Gondwana sequence of India. The Jabalpur Formation represents a later stage of Gondwana deposition during the Jurassic and Early Cretaceous. The Kota Formation is famous for its rich fossil record, including fish and various reptiles. These units provide important information on the terrestrial environments and biological life that existed during the middle to late stages of Gondwanaland's history.

279. (D) Ammonites first appeared in the Cambrian.
The evolutionary history of marine life shows that ammonites did not appear during the Cambrian Period. Instead, they first emerged during the Devonian Period from earlier nautiloid ancestors. They subsequently flourished throughout the Mesozoic before becoming extinct at the end of the Cretaceous. Other statements, such as the extinction of trilobites at the end of the Permian and the use of graptolites as index fossils, are accurate paleontological facts.

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280. (A) Siwalik Group
The Siwalik Group is world-renowned for providing an exceptionally detailed record of vertebrate evolution during the Neogene and Quaternary periods. This record includes numerous fossils that document the evolution of the horse, showing a clear progression toward larger body sizes, more complex teeth for grazing, and a reduction in the number of toes. These findings are critical for understanding mammalian adaptation to the expanding grasslands of Asia.

281. (C) The total organic matter (including palynomorphs) in a sedimentary rock, used to interpret depositional environments
Palynofacies refers to the total organic content preserved within a sedimentary rock as seen under a microscope. This includes not only

of the Palaeozoic Era. They were particularly abundant and diverse during the Ordovician and Silurian periods. Because they evolved rapidly and were widely distributed by ocean currents, they serve as excellent index fossils. Their study is fundamental for establish precise biostratigraphic zonations and correlating Palaeozoic marine strata across various continents and ocean basins worldwide.

249. (C) A dinosaur footprint
A dinosaur footprint is a classic example of a trace fossil, also known as an ichnofossil. Trace fossils represent the preserved record of an organism's behavior or biological activity rather than its actual body parts. Footprints, trails, and burrows provide unique information about how ancient animals moved, interacted with their environment, and behaved, which cannot always be determined from the study of skeletal remains or other body fossils.

250. (A) To control buoyancy by regulating gas and fluid in the chambers
The siphuncle is a specialized tube found in the chambered shells of cephalopods like nautiloids and ammonites. Its primary function was to regulate the relative amounts of gas and liquid within the individual chambers. By doing so, the organism could precisely control its buoyancy, allowing it to move up and down in the water column or maintain a stable position. This adaptation was essential for their free-swimming marine lifestyle.

251. (D) Reptiles
Reptiles were the first vertebrate group to evolve the amniotic egg. This revolutionary adaptation featured a protective, semi-permeable shell and internal membranes that provided the embryo with an aquatic environment. This allowed reptiles to reproduce and lay their eggs on land, freeing them from the requirement of returning to water for breeding. This significant evolutionary step enabled the colonization of diverse terrestrial habitats across the entire globe.

252. (B) The wall composition and structure of the test
The primary classification of foraminifera is based on the chemical composition and physical structure of their protective tests. These tests can be made of secreted calcium carbonate in various forms, such as hyaline, porcelaneous, or microgranular. Alternatively, they can be agglutinated from foreign particles. These fundamental differences in test construction are genetically determined and reflect different evolutionary lineages within this diverse group of single-celled marine organisms.

253. (C) Cenozoic
The Cenozoic Era witnessed the widespread radiation of grasses, which transformed terrestrial landscapes into vast prairies and savannas. This event triggered the co-evolution of various grazing mammals, such as ancestral horses, bison, and elephants, which developed specialized teeth and digestive systems for a grass-based diet. This biological turnover profoundly shaped the modern world's ecosystems and the diversity of mammalian life found on Earth today.

254. (D) Stage - Age
Stratigraphy uses two sets of parallel terms. A stage is a chronostratigraphic unit that represents a body of rock deposited during a specific time. Its geochronologic equivalent is an age, which refers to that corresponding interval of time itself. For example, rocks of the Kimmeridgian Stage were formed during the Kimmeridgian Age. This systematic terminology ensures clarity when distinguishing between the physical rock record and the passage of geological time.

255. (A) Proterozoic mobile belts
The ancient Archaean cratons of India, such as the Dharwar, Singhbhum, and Bastar cratons, are separated by younger Proterozoic mobile belts. These belts, like the Eastern Ghats and the Central Indian Tectonic Zone, represent areas of intense tectonic activity, metamorphism, and deformation. They mark the boundaries where different crustal blocks collided and were stitched together, forming the foundational architecture of the modern Indian Peninsular Shield.

256. (C) Statement I is true but Statement II is false.
The Vindhyan basin is a major Purana basin of India, representing a long period of Proterozoic sedimentation. Its rocks are economically significant for building stones and limestone. However, they do not contain coking coal. In India, metallurgical and thermal coal are almost exclusively found within the much younger

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provides an important record of the tectonic, environmental, and biological conditions during this long interval of Precambrian history following the stabilization of the southern cratons.

224. (B) Talchir Formation
The Talchir Formation marks the beginning of the Gondwana sequence in India. It is geologically significant because it contains distinctive boulder beds, known as tillites, which are of glacial origin. These deposits provide compelling evidence that the Indian subcontinent experienced cold, glacial conditions during the Early Permian. This formation serves as a critical climate marker for the onset of the long-term Gondwana sedimentary history.

225. (B) Siwalik Group
The Siwalik Group consists of thick sequences of fluvial sediments deposited in the Himalayan foreland basin. These rocks are internationally famous for their rich vertebrate fossil content, including ancestors of modern elephants, horses, and various large mammals. The presence of these fossils within a sequence of sandstones and conglomerates is a diagnostic feature of the Siwalik strata, representing the environmental conditions of the Neogene Period in Asia.

226. (A) For correlation and dating of rock strata
Index fossils are indispensable tools for geologists because they allow for the correlation and dating of rock layers across different regions. To be effective, an index fossil must have been geographically widespread and existed for a relatively short geological duration. By identifying these fossils in separate rock sequences, scientists can establish that the layers were deposited during the same specific time interval, regardless of their location.

227. (C) Cephalon, thorax, and pygidium
The body of a trilobite is divided into three distinct segments from front to back. The cephalon is the rigid head shield, the thorax is the flexible middle section composed of multiple segments, and the pygidium is the fused tail shield. This anatomical division allowed the trilobite to roll up for protection. Together with the three-lobed longitudinal division, this structure is a defining characteristic of the trilobite exoskeleton.

228. (C) Statement I is true but Statement II is false.
Brachiopods have two valves of unequal size, and each valve is symmetrical across its midline, perpendicular to the hinge. Lamellibranchs, or bivalves, typically have two valves that are equal mirror images of each other. However, individual lamellibranch valves are generally inequilateral, meaning they are asymmetrical about their midline. This difference in shell symmetry is a fundamental morphological distinction used to identify these two fossil groups.

229. (D) 1, 2 and 3
Mesozoic stratigraphy in India is remarkably rich and diverse. The Triassic of Spiti is world-renowned for its Ceratites and other ammonite fossils. Similarly, the Jurassic of Kutch contains an incredible variety of ammonites used for global correlation. The Cretaceous sequence in South India, particularly the Trichinopoly area, is famous for its abundant marine invertebrate fossils, recording a significant period of sea-level transgression and marine ecosystem development.

230. (B) Late Triassic
The first true mammals appeared in the fossil record during the Late Triassic Period. They evolved from specialized mammal-like reptiles called cynodonts. These early mammals were generally small, nocturnal creatures that lived alongside the early dinosaurs. While they remained relatively small throughout the Mesozoic, they established the biological foundations that eventually led to the massive diversification of mammalian orders following the end-Cretaceous extinction event.

231. (D) The Glossopteris Flora
The Gondwana flora is frequently referred to as the Glossopteris flora due to the overwhelming dominance of that specific plant genus. Glossopteris was a seed-bearing fern with tongue-shaped leaves that flourished in the cold to temperate climates of Gondwanaland during the Permian Period. Its widespread fossil record across the southern continents was central to proving that these landmasses were once connected as a single, massive supercontinent.

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265. (C) Earth's magnetic field reversals preserved in rocks
Magneto-stratigraphy is a correlation technique based on the Earth's history of magnetic field reversals. As rocks form, certain minerals record the polarity of the magnetic field at that time. By identifying sequences of normal and reversed polarity, geologists can create a global magnetic polarity time scale. This allows for the precise correlation of rock strata across vast distances, independent of lithology or the presence of fossils.

266. (A) Marwar
The Indian Peninsular Shield is composed of several major ancient cratonic blocks. The Dharwar, Singhbhum, and Bastar cratons are well-known examples of these stable Archaean crustal provinces. Marwar, however, is not considered one of these primary Archaean cratons. It is instead associated with younger Proterozoic and Palaeozoic sequences in northwestern India, which were deposited long after the stabilization of the older cratonic cores.

267. (D) The Archaean basement from the Proterozoic sedimentary cover
The Great Eparchaean Unconformity is a major geological boundary in Indian stratigraphy. it represents a prolonged period of erosion and non-deposition that occurred after the stabilization of the Archaean basement and before the deposition of the Proterozoic sedimentary sequences, such as the Cuddapah and Vindhyan Supergroups. This unconformity is visible across many parts of the Indian Peninsula and marks a fundamental change in regional tectonic style.

268. (B) The rapid appearance and diversification of most major animal phyla.
The Cambrian Explosion was a pivotal event in Earth's history, occurring approximately 541 million years ago. It marks the relatively sudden and widespread appearance of a diverse array of complex, multicellular organisms in the fossil record. During this brief geological interval, most of the major animal phyla observed today, including arthropods, molluscs, and chordates, first emerged, fundamentally changing the nature of marine ecosystems forever.

269. (C) Limestone, gypsum, and celestite
The Cretaceous formations of South India are geologically significant and economically important. These groups, including the Uttatur and Ariyalur, contain thick sequences of marine sediments that host various industrial minerals. High-quality limestone is extracted for the cement industry, and deposits of gypsum and celestite are also found. These resources have made the Cauvery Basin a critical region for mineral production and stratigraphic research in India.

270. (A) Both A and R are true and R is the correct explanation of A.
The Siwalik hills are world-renowned for their rich vertebrate fossil record. This is largely due to the high rates of sedimentation in the fluvial environment of the Himalayan foreland basin. As rivers carried huge amounts of sediment from the rising mountains, the remains of animals living on the floodplains were quickly buried. This rapid burial protected the bones from scavengers and weathering, facilitating their preservation as fossils.

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271. (A) Amber or ice
Preservation of entire organisms, including soft tissues like flesh and skin, is exceptionally rare in the fossil record. It typically requires unique conditions that prevent decay. Amber, which is fossilized tree resin, can trap and preserve small insects and animals with incredible detail. Similarly, permanent ice can entomb large mammals, such as mammoths, keeping their soft parts intact for thousands of years. Conventional sedimentary rocks usually preserve only hard parts.

272. (B) Reduction in the number of stipes and development of a float (nema)
Graptoloids became successful planktonic organisms through several key evolutionary adaptations. One significant change was the reduction in the number of branches, or stipes, which improved stability in the water column. Additionally, the development of a nema, or thin thread, possibly allowed them to attach to floating seaweed or floats. These modifications helped them disperse across ancient oceans, making them excellent index fossils for the early Palaeozoic.

Gondwana Supergroup, which was deposited during the Permian and Triassic periods in fault-bounded river basins.

257. (B) P-2, Q-3, R-4, S-1
Specific fossils are characteristic of different Indian stratigraphic units. Stegodon is a common fossil mammal in the Siwalik Group. Pachydiscus is a well-known ammonite from the Cretaceous of South India. Perisphinctes is a diagnostic Jurassic ammonite from Kutch. Productus is a prominent brachiopod from the Permian of the Salt Range. These fossils are vital for dating rock layers and establishing regional and global stratigraphic correlations.

258. (A) The Peninsular shield (Narmada Valley)
The Bagh Beds provide evidence for a marine transgression that occurred during the Cretaceous Period along the Narmada Valley. This sea flooded into the interior of the Indian Peninsular Shield, depositing a sequence of fossiliferous marine sediments. The presence of these beds highlights the dynamic nature of sea-level changes during the Mesozoic and helps geologists reconstruct the ancient palaeogeography of central and western India.

259. (C) It provides evidence for a widespread Permo-Carboniferous glaciation.
The Talchir Boulder Bed, a distinctive tillite found at the base of the Gondwana Supergroup, is of great palaeoclimatic significance. It consists of unsorted rock fragments in a fine-grained matrix, which is a hallmark of glacial deposition. This evidence proves that a major glaciation event covered much of the southern supercontinent Gondwanaland, including India, during the transition from the Carboniferous to the Permian Period.

260. (B) 2 and 3 only
An ideal index fossil must possess specific characteristics to be useful for dating and correlation. It should have a wide geographical distribution to allow for correlation between different regions and must be abundant and easily recognizable. Crucially, it must have a short geological range, meaning it existed for only a brief time. A long-ranging fossil is not useful because it cannot pinpoint a specific time interval.

261. (C) Lophophore
The lophophore is the specialized feeding and respiratory organ in brachiopods. It consists of a ciliated, often coiled or horseshoe-shaped structure that captures plankton and other food particles from the surrounding seawater. Although the soft tissue of the lophophore is rarely preserved, its presence and size can often be inferred in fossils by the calcareous skeletal supports, called brachidia, found within the brachiopod shell.

262. (B) Brachiopods are equilateral, lamellibranchs are inequilateral.
Brachiopod and lamellibranch (bivalve) shells are distinguished by their symmetry. In brachiopods, each individual valve is equilateral, meaning it is symmetrical about its midline. However, the two valves themselves are unequal in size. In contrast, typical lamellibranchs have two equal valves, but each individual valve is inequilateral or asymmetrical. This fundamental morphological difference is a primary tool used by paleontologists to correctly identify and classify these two fossil groups.

263. (D) Jawless fishes (Agnathans)
The first vertebrates to appear in the fossil record were the agnathans, or jawless fishes. These primitive organisms lived in early Palaeozoic oceans and were characterized by a lack of jaws and paired fins. Some early forms, such as ostracoderms, developed heavy bony armor for protection. The evolution of agnathans represents the initial radiation of the vertebrate lineage, eventually leading to the development of jawed fish and all subsequent land animals.

264. (A) Fossil spores, pollen, and other palynomorphs
Palynology is the specialized study of organic-walled microfossils, which include pollen, spores, and various other palynomorphs. These structures are produced in large quantities and are highly resistant to degradation, making them valuable for geological research. Palynology is used to correlate rock layers, reconstruct ancient vegetation, and interpret past climates. It is also an essential tool in the petroleum industry for evaluating the age and maturity of source rocks.

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palynomorphs like pollen and spores but also organic debris such as wood fragments and leaf cuticles. By analyzing the composition and preservation of this organic matter, geologists can accurately interpret the ancient depositional environment, such as whether it was a swamp, river, or marine setting.

282. (A) Principle of Original Horizontality
The Principle of Original Horizontality is a fundamental rule in stratigraphy. it states that most sedimentary layers are originally deposited as flat-lying, horizontal beds. If rock layers are found in a tilted or folded position, it indicates that they have been subjected to tectonic forces and deformation after their initial deposition. This concept allows geologists to reconstruct the structural history and deformation of rock sequences in various geological settings.

283. (A) Both Statement I and Statement II are true.
India is geologically divided into two contrasting regions. The Indian Shield is an ancient cratonic block composed of stable Precambrian rocks that have not undergone major orogenic deformation for billions of years. In contrast, the Himalayas represent a young, tectonically active mountain range formed by the ongoing collision between the Indian and Eurasian plates. This dynamic boundary continues to shape the topography and geology of the entire northern subcontinent.

284. (A) 1 and 2 only
The Proterozoic Purana basins of India, such as the Cuddapah and Vindhyan, share several characteristics. The Cuddapah basin has a distinct crescent shape, while the Vindhyan basin is noted for its stromatolite-bearing limestones. However, unlike younger basins, these Proterozoic basins are not major repositories of petroleum in India. Their economic importance instead lies in building stones, limestone for cement, and various other industrial minerals essential for the national economy.

285. (C) Triassic, Jurassic, Cretaceous
The Mesozoic Era, often called the Age of Dinosaurs, is divided into three distinct geological periods. It began with the Triassic, followed by the Jurassic, and ended with the Cretaceous Period. This era witnessed major evolutionary events, including the rise of dinosaurs, the evolution of mammals and birds, and the breakup of the supercontinent Pangaea. The era concluded with a massive extinction event approximately 66 million years ago.

286. (D) Permian
The most catastrophic mass extinction in Earth's history occurred at the end of the Permian Period. It is estimated that approximately 96% of all marine species and 70% of terrestrial vertebrate species became extinct during this event. This global biological crisis was much more severe than the extinction that later killed the dinosaurs. It fundamentally reset the course of evolution, leading to the emergence of entirely new ecosystems during the Mesozoic Era.

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287. (C) P-4, Q-2, R-1, S-3
Indian stratigraphic units are found in specific geographic regions. The Dharwar Supergroup is characteristic of Karnataka in South India. The Siwalik Group is located along the Himalayan foothills. The Vindhyan Supergroup forms the structural core of the Vindhya Range in central India. Finally, the Gondwana Supergroup is primarily found within fault-bounded river valleys like the Damodar and Godavari, where its vast coal reserves are concentrated.

288. (B) Periods of non-deposition and soil formation on ancient floodplains
The presence of caliche or palaeosol horizons within the Siwalik sequence is a significant palaeoenvironmental indicator. These layers represent ancient soil profiles that formed when sedimentation on the floodplains temporarily ceased. They provide evidence for alternating periods of active deposition by rivers and intervals of stability and soil development. Studying these horizons helps geologists reconstruct the ancient climate and the dynamics of the Himalayan foreland basin during the Neogene.

289. (B) Echinodermata
Five-fold radial symmetry, also known as pentameral symmetry, is a defining characteristic of the phylum Echinodermata. This group includes modern organisms like starfish, sea urchins, and crinoids, as well as many extinct forms. While their larvae are bilaterally symmetrical, adult echinoderms develop this unique five-part body plan. This symmetry is

reflected in their skeletal structures, such as the plates of an echinoid test or the arms of a starfish.

290. (A) First-formed embryonic chamber of the shell
In cephalopods, the protoconch is the initial chamber formed during the embryonic stage of development. As the organism grows, it adds new chambers sequentially, but the protoconch remains at the apex of the shell. Studying the size and shape of the protoconch is important for understanding the early life history and evolutionary relationships of various cephalopod groups, including both nautiloids and the extinct ammonites.

291. (C) Cenozoic
While angiosperms, or flowering plants, first appeared during the Cretaceous Period, they underwent a massive radiation and became the dominant group of land plants during the Cenozoic Era. Their evolution of complex flowers and fruits facilitated diverse reproductive strategies and co-evolution with pollinators. Today, angiosperms comprise the vast majority of terrestrial plant species and form the basis of most modern ecosystems and human agricultural systems worldwide.

292. (D) Archaean and the Dravidian
In the classic classification of Indian stratigraphy, the Purana group of rocks occupies a position between the older Archaean and the younger Dravidian sequences. The Purana formations, such as the Cuddapah and Vindhyan Supergroups, represent a long period of Proterozoic sedimentation following the stabilization of the ancient shield. This terminology helps geologists organize the complex Precambrian and early Palaeozoic history of the Indian subcontinent into broad, recognizable stages.

293. (C) Petroleum and Coal
The Tertiary rocks of Assam are of immense economic importance because they host major energy resources. Significant reserves of petroleum are found in various sandstone reservoirs, while thick coal seams occur within the Barail Group. These resources have driven the industrial development of northeastern India for over a century. The unique geological setting of the Assam basin has facilitated the accumulation and preservation of these vital fossil fuel deposits.

294. (B) Permian period
Trilobites were a highly successful and diverse group of marine arthropods that lived throughout the Palaeozoic Era. However, their long evolutionary history came to an end during the mass extinction at the conclusion of the Permian Period. This global catastrophe resulted in the disappearance of the last remaining trilobite lineages, along with many other marine invertebrates, marking one of the most significant biological turnovers in the Earth's entire history.

295. (D) Radiolaria
Radiolaria are a group of single-celled marine protists that construct intricate and often beautiful skeletons made of silica. Unlike foraminifera, which typically have calcareous tests, radiolarians secrete silica directly from the seawater. After death, their durable skeletons sink to the ocean floor, where they can accumulate to form siliceous oozes. Radiolaria have a long fossil record and are valuable for biostratigraphy and for reconstructing ancient oceanographic conditions.

296. (A) Eastern India
The Singhbhum region is a major geological province located in eastern India, primarily within the state of Jharkhand. This area is internationally famous for its ancient Archaean rocks, which include some of the oldest crustal fragments on the Indian subcontinent. The region is of immense economic importance due to its rich deposits of iron, copper, and uranium, making it a critical hub for geological research and mineral production.

297. (C) Himalayas (Spiti, Kashmir)
The Muth Quartzite is a prominent and geographically widespread stratigraphic unit of Devonian age found in the Tethyan Himalayan region, including Spiti and Kashmir. This hard, white quartzite formation represents a period of stable, shallow marine deposition along the northern margin of Gondwanaland. Its distinct lithology makes it an important marker bed for geologists working on the Palaeozoic stratigraphy of the Himalayan mountain range.

298. (A) Mesozoic
The coexistence of dinosaurs and ammonites is a definitive indicator of the Mesozoic Era.

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Dinosaurs were the dominant terrestrial vertebrates, while ammonites were abundant and diverse in the oceans throughout the Triassic, Jurassic, and Cretaceous periods. Since both groups became extinct at the end of the Cretaceous, their fossil remains are only found together in rocks deposited during this significant 180-million-year interval of Earth's history.

299. (A) Both A and R are true and R is the correct explanation of A.
Microfossils like foraminifera and ostracods are essential for subsurface correlation in the petroleum industry. When drilling for oil, large fossils are typically crushed into unidentifiable fragments by the drill bit. However, microfossils are small enough to be recovered completely intact from the rock cuttings. Their rapid evolution and abundance allow geologists to establish high-resolution biostratigraphic zones, which are crucial for accurately matching rock layers between different well sections.

300. (B) Globular shape with near-perfect pentameral symmetry, with the mouth on the lower surface and anus on the upper surface.
Regular echinoids are characterized by a globular or spherical test that exhibits near-perfect pentameral symmetry. Their morphology includes a mouth located on the lower surface, known as the oral side, and an anus positioned at the apex on the upper surface, or aboral side. These organisms are typically epifaunal, living on the seafloor and using their spines for movement and defense in ancient and modern oceans.

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identify areas of high groundwater potential.
(B) To drill borewells and test water quality.
(C) To create a database of all geologists in the region.
(D) To purify contaminated groundwater using digital filters.

67. Arrange the following tasks for a geological site investigation of a dam in a logical sequence.
1. Detailed drilling, trenching, and geophysical surveys at the selected site.
2. Final design based on detailed site data.
3. Regional study using maps and remote sensing to identify potential areas.
4. Preliminary field reconnaissance of potential areas to narrow down choices.

Choose the correct answer from the options given below:
(A) 3, 4, 1, 2
(B) 1, 2, 3, 4
(C) 4, 3, 2, 1
(D) 3, 1, 4, 2

68. The displacement of the image of a tall building on a vertical aerial photograph is an example of:
(A) Tilt displacement
(B) Crab displacement
(C) Drift displacement
(D) Relief displacement

69. Which statement is true regarding the reflectance of minerals, vegetation, rock, and water?
(A) Water reflects strongly in the near-infrared, appearing bright.
(B) Most rocks have a uniform reflectance across the entire spectrum.
(C) Healthy vegetation shows low reflectance in the green and high reflectance in the near-infrared.
(D) The reflectance of a mineral is independent of its grain size.

70. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : Tunnels constructed through alternating sequences of hard and soft rock layers require special engineering considerations.
Reason (R) : The differential behavior of hard and soft rocks under stress can lead to uneven loading on the tunnel lining, potentially causing structural failure.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

71. Energy interaction with the Earth's surface" is a fundamental concept in remote sensing. Which process is NOT a part of this interaction?
(A) Reflection
(B) Absorption
(C) Transmission
(D) Refraction within the sensor's lens

72. In photo-geologic interpretation, the term 'background knowledge' refers to:
(A) Pre-existing information about the geology, climate, and vegetation of the study area.
(B) The interpreter's understanding of camera mechanics.
(C) The ability to see the background of a stereoscopic image.
(D) The type of film used for the background of the photograph.

73. Match List I with List II.
List I: (GIS Term)
P. Vector Data
Q. Raster Data
R. Attribute Data
S. Overlay Analysis
List II: (Description)
1. A grid of cells or pixels, each with a value.
2. Non-spatial information about a geographic feature (e.g., name, type).
3. The process of superimposing multiple data layers to derive new information.
4. Representation of geographic features as points, lines, and polygons.

Choose the correct answer from the options given below:
(A) P-1, Q-4, R-3, S-2
(B) P-4, Q-1, R-2, S-3
(C) P-4, Q-2, R-1, S-3
(D) P-2, Q-1, R-3, S-4

74. The geometric distortion in an aerial photograph where the ground appears to be tilted is called:
(A) Tilt

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(C) A photographic camera using sunlight.
(D) A Side-Looking Airborne Radar (SLAR) system.

8. Consider the following statements about photo-geologic maps:
(i) They are prepared by interpreting geological features directly from aerial photographs.
(ii) They typically show more detail about surficial deposits than traditional geological maps.
(iii) They eliminate the need for any field verification or ground-truthing.
Which of the above statement(s) is/are correct?
(A) (i) only
(B) (i) and (ii) only
(C) (ii) and (iii) only
(D) (i), (ii) and (iii)

9. What is the effect of 'vertical exaggeration' in the stereoscopic viewing of aerial photographs?
(A) It makes the terrain appear flatter than it actually is.
(B) It makes all features appear smaller than their actual size.
(C) It causes the vertical scale to appear larger than the horizontal scale, accentuating relief.
(D) It corrects for all tilt and relief distortions in the photograph.

10. Match List I with List II.
List I: (Remote Sensing Sensor)
P. LISS Camera
Q. TIRLS
R. SAR
S. Aerial Film Photography
List II: (Primary EMR Region Used)
1. Microwave
2. Visible
3. Visible and Near Infrared (NIR)
4. Thermal Infrared
Choose the correct answer from the options given below:
(A) P-3, Q-4, R-1, S-2
(B) P-2, Q-1, R-4, S-3
(C) P-3, Q-4, R-2, S-1
(D) P-4, Q-3, R-1, S-2

11. What is the primary cause of relief displacement in a single vertical aerial photograph?
(A) The tilt of the aircraft at the time of exposure.
(B) The curvature of the Earth.
(C) The atmospheric scattering of light.
(D) The variation in elevation of the ground surface.

12. In the context of engineering properties of rocks, what does 'compressive strength' measure?
(A) The rock's ability to resist forces that tend to pull it apart.
(B) The rock's ability to resist forces that tend to crush it.
(C) The rock's ability to resist weathering and chemical decay.
(D) The rock's ability to allow fluids to pass through it.

13. Which of the following is NOT a controlling factor considered during the planning of an aerial photography mission?
(A) Scale of the photograph
(B) Purpose of the photography
(C) The brand of the GPS unit used by the ground crew
(D) Time and season of photography

14. Arrange the following steps in a typical remote sensing data acquisition and analysis workflow in chronological order:
1. Data Analysis and Interpretation
2. Energy Interaction with the Atmosphere and Earth's Surface
3. Energy Source or Illumination
4. Transmission, Reception, and Processing
5. Sensing by the Sensor
Choose the correct answer from the options given below:
(A) 3, 2, 5, 4, 1
(B) 1, 3, 2, 5, 4
(C) 3, 5, 2, 1, 4
(D) 5, 4, 3, 2, 1

15. Reflectance of which of the following is generally highest in the Near Infrared (NIR) region?
(A) Healthy green vegetation
(B) Clear water
(C) Dry, sandy soil
(D) Asphalt pavement

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50. The process of creating a continuous photographic representation of an area by assembling individual aerial photos is called:
(A) Mosaicking
(B) Rectification
(C) Georeferencing
(D) Stereoscopy

51. Arrange the following remote sensing sensors based on the general decreasing wavelength they primarily operate in.
1. Side-Looking Airborne Radar (SLAR)
2. Thermal Infra-Red Line-Scanner (TIRLS)
3. Multi-Spectral Scanner (MSS) - Visible Bands
4. Near Infrared (NIR) Camera

Choose the correct answer from the options given below:
(A) 3, 4, 2, 1
(B) 1, 2, 4, 3
(C) 1, 2, 3, 4
(D) 3, 2, 1, 4

52. In microwave remote sensing (Radar), the sensor's ability to penetrate cloud cover, light rain, and operate at night is a significant advantage. This is because:
(A) Microwaves are not affected by atmospheric particles at all.
(B) Microwave sensors are passive and only collect heat.
(C) Radar systems use visible light which can be focused through clouds.
(D) Longer microwave wavelengths are not significantly scattered by small particles or lack of sun.

53. Which of the following statements about image processing is incorrect?
(A) Image restoration aims to correct for distortions and degradations in an image.
(B) Image enhancement techniques are applied to make certain features or patterns more discernible to the human eye.
(C) Discrete image processing involves treating the image as a continuous function of brightness.
(D) Image classification is a process of automatically categorizing pixels into different classes or themes.

54. The geological investigation for a major bridge focuses on:
(A) The permeability of the riverbed for water supply.
(B) The bearing capacity and stability of the rock or soil at the locations of piers and abutments.
(C) The vegetation types found on the river banks.
(D) The historical flood levels of the river.

55. Match List I with List II.
List I: (Interpretation Element)
P. Pattern
Q. Tone
R. Texture
S. Size
List II: (Geological Example)
1. Light-colored appearance of dry sand versus dark tone of wet soil.
2. The large, circular shape of a volcanic caldera compared to a small sinkhole.
3. The regular, grid-like arrangement of joints in some rock types.
4. The coarse, mottled appearance of a conglomerate versus the fine, smooth appearance of shale.

Choose the correct answer from the options given below:
(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-1, R-4, S-2
(C) P-3, Q-4, R-1, S-2
(D) P-2, Q-1, R-4, S-3

56. 'Scattering' in the context of EMR interaction with the atmosphere refers to:
(A) The redirection of EMR from its original path by particles and gas molecules.
(B) The complete absorption of EMR by atmospheric gases.
(C) The bending of EMR as it passes from one medium to another.
(D) The process of an object emitting its own EMR.

57. The purpose of a flight plan in an aerial survey is to:
(A) Ensure the aircraft has enough fuel for the entire mission.
(B) Obtain permission from air traffic control.
(C) Specify the flight lines, flying height, and

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R. Mosaic
S. Tilt

List II: (Description)

1. An assembly of individual aerial photos to form a continuous picture of an area.
2. The ratio of the distance on a photograph to the corresponding distance on the ground.
3. The angular displacement of the camera axis from the vertical.
4. The amount by which one photograph includes the area covered by another.

Choose the correct answer from the options given below:

(A) P-2, Q-4, R-1, S-3
(B) P-1, Q-2, R-4, S-3
(C) P-2, Q-3, R-1, S-4
(D) P-4, Q-1, R-3, S-2

25. What is the fundamental difference between an active and a passive remote sensor?

(A) Active sensors work only during daylight hours, while passive sensors work exclusively during the night.
(B) Active sensors generally possess significantly higher spatial resolution than all types of passive sensors.
(C) Active sensors provide their own illumination source, while passive sensors detect external energy.
(D) Passive sensors are deployed on satellites, while active sensors are restricted to airborne platforms.

26. Which of the following is NOT a primary element of interpretation of aerial photographs?

(A) The price of the camera lens
(B) Tone and color
(C) Texture and pattern
(D) Shape and size

27. The term 'SAR' in remote sensing is an acronym for:

(A) Satellite-Assisted Radar
(B) Spectral Analysis Radiometer
(C) Side-Angle Reflectance
(D) Synthetic Aperture Radar

28. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A) : In remote sensing, clear, deep water bodies appear dark in the near-infrared (NIR) bands.

Reason (R) : Water is a strong absorber of near-infrared radiation, and therefore reflects very little energy in this part of the spectrum back to the sensor.

(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

29. The purpose of lining a tunnel, especially in weak or fractured rock, is primarily to:

(A) Provide a smooth surface for aesthetic purposes.
(B) Improve the acoustic properties inside the tunnel.
(C) Support surrounding rock mass, prevent collapse, and control groundwater seepage.
(D) Provide a pathway for utility cables and pipes only.

30. In image processing, what is the difference between a continuous and a discrete image?

(A) A continuous image is entirely digital, while a discrete image is purely analog in nature.
(B) Continuous images are always black and white, while discrete images are always in color.
(C) Continuous images are from active sensors, and discrete images are from passive sensors.
(D) A continuous image has values at every point in a plane, while a discrete image is a pixel grid.

31. Which of the following is an important geological consideration when constructing a highway?

(A) The stability of slopes in cuts and fills, and the bearing capacity of the ground.
(B) The availability of scenic viewpoints along the route.
(C) The number of lanes the highway will have.
(D) The type of vehicles expected to use the highway.

32. Arrange the following EMR wavelengths from shortest to longest.

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CHAPTER 07

Photogeology and remote sensing and Engineering Geology

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1. What is the primary purpose of multi-spectral photography in photogeology?
(A) To record photographic images in a single, broad spectral band of the electromagnetic spectrum.
(B) To record photographic images simultaneously in several different, narrow spectral bands.
(C) To produce three-dimensional terrain models through the use of overlapping stereoscopic pairs.
(D) To record photographic images exclusively within the thermal infrared region of the spectrum.

2. Which of the following statements regarding the geometric principles of aerial photographs is correct?
(A) Vertical exaggeration is the perceived stretching of the vertical scale relative to the horizontal scale in a stereo model.
(B) Relief displacement is the horizontal shift of an object's image due to its elevation, and it is directed radially inward from the nadir.
(C) Tilt displacement is caused by the elevation of the terrain and is uniform across the entire photograph.
(D) All distortions in an aerial photograph can be completely eliminated through simple geometric corrections.

3. In aerial photography, what does the term 'drift' refer to?
(A) The intentional tilting of the camera axis from the vertical.
(B) The progressive increase in the scale of photographs as the aircraft descends.
(C) The lateral shift of the aircraft from the planned flight line, caused by wind.
(D) The rotation of the camera in its mount to compensate for aircraft movement.

4. Which type of electromagnetic radiation (EMR) is primarily utilized by Thermal Infra-Red Line-Scanners (TIRLS)?
(A) Reflected solar energy in the visible spectrum.
(B) Microwave energy transmitted from the sensor itself.
(C) Reflected solar energy in the near-infrared region.
(D) Emitted thermal energy from the Earth's surface.

5. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : The selection of a dam site requires a thorough geological investigation of the area.
Reason (R) : The stability and water-tightness of a dam and its reservoir are fundamentally dependent on the underlying geology, such as rock type, structural defects, and permeability.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

6. The ability of a remote sensing system to distinguish between different wavelengths of EMR is known as its:
(A) Spatial resolution
(B) Spectral resolution
(C) Temporal resolution
(D) Radiometric resolution

7. Which of the following is an example of an active sensor used in remote sensing?
(A) A LISS camera on an IRS satellite.
(B) A Multi-Spectral Scanner (MSS).

41. In remote sensing, what does LISS stand for?
(A) Light Imaging Self-Scanner
(B) Low-Illumination Spectral System
(C) Linear Imaging Self-Scanning Sensor
(D) Land Information Survey Satellite

42. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : Background knowledge of the geology of an area is crucial for the effective interpretation of aerial photographs.
Reason (R) : Understanding the regional geology helps the interpreter to correctly identify lithological units, structures, and landforms that might otherwise be ambiguous on the photograph.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

43. Which of the following is NOT an engineering property of a rock relevant to civil engineering projects?
(A) Compressive strength
(B) Porosity and permeability
(C) Shear strength
(D) Fossil content and age

44. The main advantage of multi-spectral photography over panchromatic (black and white) photography is:
(A) It provides higher spatial resolution.
(B) It allows for the differentiation of surface materials based on their unique spectral signatures.
(C) It is significantly cheaper to acquire.
(D) It inherently provides a 3D view without needing stereopairs.

45. The term 'sidelap' in an aerial survey refers to:
(A) The overlap between consecutive photos in a single flight line.
(B) The tilting of the aircraft towards the side.
(C) The overlap between photos from two adjacent, parallel flight lines.
(D) The unusable area on the side edges of a photograph.

46. In the context of remote sensing, the reflectance of a material is defined as:
(A) The total amount of energy absorbed by the material.
(B) The energy emitted by the material as heat.
(C) The amount of energy scattered by the material into the atmosphere.
(D) The ratio of the energy reflected from a material to the energy incident upon it.

47. What is a primary application of GIS in engineering geology?
(A) Integrating and analyzing spatial data (e.g., geology, slopes, faults) for hazard zonation and site selection.
(B) Performing rock strength tests in a virtual environment.
(C) Creating 3D models of proposed building structures.
(D) Directly controlling construction machinery on-site.

48. Consider the following statements about satellite platforms:
(i) A geostationary satellite orbits the Earth at the same speed as the Earth's rotation, appearing stationary from the ground.
(ii) A sun-synchronous satellite passes over any given point on the Earth's surface at the same local solar time.
(iii) Sensor platforms are limited to satellites and cannot be mounted on aircraft.
Which of the above statement(s) is/are correct?
(A) (i) and (ii) only
(B) (ii) and (iii) only
(C) (i) and (iii) only
(D) (i), (ii) and (iii)

49. Which of the following geological features is most easily identified on aerial photographs by its distinct drainage pattern, such as a trellis pattern?
(A) A massive igneous intrusion like a granite batholith.
(B) A region of folded sedimentary rocks with alternating resistant and non-resistant beds.
(C) An area of flat-lying, uniform sedimentary rock.
(D) A volcanic cone.

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16. What is the term for the marks, usually in the corners or on the sides of an aerial photograph, that define the coordinate system of the photo?
(A) Nadir points
(B) Principal points
(C) Fiducial marks
(D) Isocenters

17. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : Passive remote sensing systems can operate effectively at any time of day or night.
Reason (R) : Passive sensors rely on detecting naturally reflected or emitted energy from the Earth's surface, primarily solar radiation.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

18. Which statement incorrectly describes the interaction of EMR with the atmosphere?
(A) Rayleigh scattering affects longer wavelengths more significantly than shorter wavelengths.
(B) Scattering is the unpredictable diffusion of radiation by particles in the atmosphere.
(C) Absorption is the process by which radiant energy is converted into other forms of energy by atmospheric constituents like ozone and water vapor.
(D) Atmospheric windows are portions of the spectrum that transmit energy effectively.

19. A key geological consideration for the construction of a tunnel is:
(A) The aesthetic appeal of the surrounding landscape.
(B) The proximity to major urban centers.
(C) The presence of competent rock with minimal structural defects like faults and joints.
(D) The local wind speed and direction.

20. A GIS (Geographic Information System) is best described as:
(A) A complex hardware system designed primarily for capturing high-resolution satellite images and terrain data.
(B) A specialized software program used exclusively for creating digital maps and cartographic representations.
(C) A global satellite navigation device used for determining precise spatial locations on the Earth's surface.
(D) A system designed to capture, store, manipulate, analyze, manage, and present all types of geographical data.

21. Consider the following statements regarding aerial photography parameters:
(i) Overlap is the amount by which one photograph in a flight line covers the area of the next photograph, and it is typically around 60%.
(ii) Sidelap is the overlap between adjacent flight lines, typically around 20-30%.
(iii) Crab is the condition where the aircraft is not oriented with the flight line, causing the photographs to be skewed.
Which of the above statement(s) is/are correct?
(A) (i) and (ii) only
(B) (ii) and (iii) only
(C) (i) and (iii) only
(D) (i), (ii) and (iii)

22. In the context of remote sensing, what does MSS" stand for?
(A) Microwave Scanning System
(B) Multi-Spectral Scanner
(C) Multi-System Sensor
(D) Manual Scene Selection

23. When selecting a site for a large reservoir, which geological condition would be most unfavorable?
(A) A thick, impermeable clay layer underlying the reservoir area.
(B) A basin structure in horizontally bedded sedimentary rocks.
(C) A foundation of massive, unweathered granite.
(D) The presence of highly fractured and cavernous limestone (karstic terrain).

24. Match List I with List II.
List I: (Photogrammetric Term)
P. Scale
Q. Overlap

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photo positions to ensure systematic and complete coverage of the target area.
(D) Calculate the final cost of the survey.

58. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : Rock type (lithology) can often be inferred from remote sensing imagery.
Reason (R) : Different rock types have distinct mineral compositions, which result in characteristic reflectance and emittance properties across the electromagnetic spectrum.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

59. The 'importance of geology in civil engineering' is primarily because:
(A) Geologists are needed to identify decorative stones for building facades.
(B) Civil engineers require a geology degree to be licensed.
(C) Geological maps are colorful and make project proposals more attractive.
(D) All structures are built on the Earth, making geology critical for design, safety, and longevity.

60. Which of the following factors does NOT typically affect an aerial photograph?
(A) The time of day and sun angle
(B) The geological age of the rocks being photographed
(C) The season of the year
(D) Atmospheric conditions like haze

61. Consider the following statements regarding dam types:
(i) An arch dam is suitable for narrow canyons with strong, competent rock abutments.
(ii) A buttress dam uses a series of supports or buttresses on the downstream side to transmit the water load to the foundation.
(iii) An embankment dam, made of earth or rock fill, is a flexible structure that can tolerate some foundation settlement.
Which of the above statement(s) is/are correct?
(A) (i) and (ii) only
(B) (ii) and (iii) only
(C) (i) and (iii) only
(D) (i), (ii) and (iii)

62. What does 'Near Infrared (NIR)' imagery primarily detect?
(A) The heat emitted by objects.
(B) The texture and roughness of a surface using microwaves.
(C) The density of atmospheric water vapor.
(D) The reflected solar radiation just beyond the visible red part of the spectrum.

63. The scale of an aerial photograph is most accurately described as a constant value only if:
(A) The terrain is perfectly flat and the photograph is perfectly vertical.
(B) The photograph is taken at noon.
(C) The camera used has a very long focal length.
(D) The aircraft is flying at a very high altitude.

64. What is the key advantage of using Synthetic Aperture Radar (SAR) over a real aperture system like SLAR?
(A) SAR is a passive system and consumes less power.
(B) SAR creates a long antenna synthetically, allowing higher spatial resolution independent of range.
(C) SAR can only be used during the daytime.
(D) SAR operates in the visible spectrum, providing color images.

65. The application of remote sensing for identifying structural features like faults and folds is based on observing:
(A) The direct measurement of stress in the rocks from space.
(B) Linear or curvilinear features, offsets in topography, and changes in rock type, drainage, and vegetation patterns.
(C) The magnetic signature of the fault gouge.
(D) The chemical composition of the air above the structures.

66. What is the primary function of a GIS in a hydrogeological study?
(A) To overlay layers of data such as rainfall, geology, land use, and slope to model and

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1. Microwave
2. Visible Light
3. Thermal Infrared
4. Near Infrared

Choose the correct answer from the options given below:
(A) 2, 4, 3, 1
(B) 1, 3, 4, 2
(C) 2, 3, 1, 4
(D) 4, 2, 3, 1

33. Which pair is incorrectly matched?
(A) Active Sensor - Radar
(B) Image Processing - GIS
(C) Passive Sensor - Thermal Scanner
(D) Photogrammetry - Stereoscopy

34. Remote sensing techniques are applied in hydrogeology studies primarily to:
(A) Map surface indicators like vegetation, moisture, and fractures to identify potential groundwater.
(B) Directly measure the depth of the water table with centimeter accuracy from an orbital platform.
(C) Analyze the chemical composition of groundwater from space using high-resolution spectral data.
(D) Construct physical borewells using satellite-guided drills and robotic engineering technologies.

35. The geometric center of a vertical aerial photograph is known as the:
(A) Isocenter
(B) Nadir
(C) Principal point
(D) Fiducial center

36. Consider the following statements about GIS:
(i) GIS data is typically organized into layers, with each layer representing a specific theme or feature type.
(ii) A key function of GIS is the ability to perform spatial analysis, such as overlay analysis and proximity analysis.
(iii) GIS can only handle vector data formats (points, lines, polygons) and not raster data (grids).

Which of the above statement(s) is/are correct?
(A) (i) only
(B) (i) and (ii) only
(C) (ii) and (iii) only
(D) (i), (ii) and (iii)

37. A 'gravity dam' is a type of dam that resists the horizontal thrust of water primarily through:
(A) Its arched shape, transferring the load to the abutments.
(B) Steel cables anchored into the foundation rock.
(C) Its own weight and the shear strength of its foundation.
(D) An impermeable upstream membrane.

38. The scale of a vertical aerial photograph taken over flat terrain is calculated using the formula:
(A) Scale = Flying height / Focal length
(B) Scale = Focal length / Flying height above ground
(C) Scale = Ground distance / Photo distance
(D) Scale = Focal length x Flying height

39. Match List I with List II.
List I: (Engineering Project)
P. Dam
Q. Tunnel
R. Highway
S. Bridge
List II: (Primary Geological Concern)
1. Stability of cut slopes
2. Nature of rock at abutments and foundation
3. Water-tightness of reservoir basin
4. Over-break and groundwater inflow

Choose the correct answer from the options given below:
(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-4, R-1, S-2
(C) P-3, Q-1, R-4, S-2
(D) P-2, Q-3, R-1, S-4

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40. What is 'tilt displacement' in an aerial photograph?
(A) Displacement of images caused by the camera lens not being perfectly vertical.
(B) Displacement of images due to the height of objects.
(C) The apparent shift in an object's position when viewed from different angles.
(D) The distortion caused by atmospheric refraction.

(B) Relief displacement
(C) Vertical exaggeration
(D) Scale variation

75. Consider the following statements:
(i) Active remote sensing systems are constrained by the availability of sunlight.
(ii) Passive remote sensing systems can measure energy in the thermal infrared region, which can be useful for night-time imaging.
(iii) Radar is a passive remote sensing system.
Which of the above statement(s) is/are correct?
(A) (ii) only
(B) (i) and (ii) only
(C) (ii) and (iii) only
(D) (i), (ii) and (iii)

76. The selection of the 'time and season of photography' for an aerial survey is important because:
(A) It affects the cost of the aircraft rental.
(B) It determines the sun angle (for shadows) and the state of vegetation cover, which can either reveal or obscure ground features.
(C) Different seasons have different air traffic regulations.
(D) The camera sensor only works in specific seasons.

77. Which of the following represents an application of remote sensing in geomorphology?
(A) Determining the precise age of a rock formation.
(B) Measuring the in-situ stress of a rock mass.
(C) Mapping landforms and analyzing drainage patterns to understand landscape evolution.
(D) Analyzing the chemical composition of minerals in a laboratory.

78. A 'photo-geologic map' is best defined as:
(A) A standard topographic map with photos printed on it.
(B) A map showing the locations where aerial photographs were taken.
(C) A collection of aerial photographs arranged in a mosaic.
(D) A geologic map prepared primarily through the interpretation of features on aerial photographs, often supplemented by field checks.

79. The engineering property of a rock that describes its ability to allow water to flow through it is:
(A) Permeability
(B) Compressive strength
(C) Porosity
(D) Density

80. A 'TIRLS' sensor is most effective for:
(A) Mapping vegetation health.
(B) Detecting thermal anomalies, such as forest fires, volcanic activity, or thermal pollution in water.
(C) Differentiating rock types based on their silica content.
(D) Measuring the height of buildings with high precision.

81. Which of the following is a primary geological consideration for canal construction?
(A) The scenic beauty of the canal route.
(B) Minimizing water loss through seepage by avoiding highly permeable materials along the route.
(C) The political boundaries the canal will cross.
(D) The availability of fishing opportunities in the canal.

82. The term 'crab' in aerial photography refers to:
(A) The misalignment of the photograph's edges with the flight line due to the aircraft's yaw.
(B) The lateral movement of the aircraft off the flight line.
(C) The failure of the camera to advance the film.
(D) The dipping motion of the aircraft's nose.

83. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : In a vertical aerial photograph, the scale is not uniform across the entire image if the terrain has relief.
Reason (R) : For points at higher elevations, the flying height above the ground is less, resulting in a larger image scale compared to points at lower elevations.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.

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154. What is the name for the type of electromagnetic radiation that has wavelengths longer than red light but shorter than microwaves?
(A) Ultraviolet
(B) Infrared
(C) X-ray
(D) Gamma ray

155. A controlling factor for an aerial photograph mosaic is its intended use. If the mosaic is to be used for precise measurements, it must be:
(A) An uncontrolled mosaic.
(B) Printed in black and white.
(C) A controlled mosaic, where photos are corrected for distortions and fitted to ground control points.
(D) Assembled as quickly as possible.

156. In GIS, combining a geological map layer with a slope map layer to find areas that have both limestone" and steep slopes" is an example of:
(A) Buffering
(B) Network Analysis
(C) Overlay Analysis
(D) Geocoding

157. Which statement accurately describes a difference between microwave and thermal infrared imagery?
(A) Microwave imagery primarily measures surface roughness and dielectric properties, while thermal infrared measures surface temperature.
(B) Microwave is a passive technique, while thermal infrared is active.
(C) Thermal infrared can penetrate clouds, but microwave cannot.
(D) Microwave imagery is only available in the daytime.

158. Consider the following geological considerations for a tunnel project:
(i) The presence of swelling clays.
(ii) High horizontal in-situ stresses in the rock mass.
(iii) The intersection of the tunnel with a major water-bearing fault.
Which of the above would pose a significant challenge to tunnel construction?
(A) (i) and (ii) only
(B) (iii) only
(C) (ii) and (iii) only
(D) (i), (ii), and (iii)

159. Height measurements from aerial photographs" are most commonly derived by measuring:
(A) The difference in parallax between the top and bottom of an object on a stereo pair.
(B) The length of shadows.
(C) The color of the object.
(D) The scale at the base of the object.

160. Which of the following is a key element in a flight plan for aerial photography?
(A) The weather forecast for the following week.
(B) The pre-determined flight lines and required overlap/sidelap percentages.
(C) The catering arrangements for the flight crew.
(D) The make and model of the ground vehicle.

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161. The reflectance of water is generally low across most of the spectrum, but it is lowest (i.e., most absorptive) in the:
(A) Blue band
(B) Green band
(C) Red band
(D) Near-infrared and beyond

162. For engineering purposes, a rock's 'compressive strength' is a critical property. Which rock type would generally be expected to have the highest compressive strength?
(A) A dense, crystalline, unweathered granite.
(B) A poorly cemented sandstone.
(C) A highly weathered shale.
(D) A soft, porous chalk.

163. The primary goal of applying photo geology and remote sensing to study 'structural features' is to:
(A) Determine the exact age of the deformation.
(B) Map the location, extent, and geometry of features like faults, folds, and joints.
(C) Directly measure the stress field responsible for the structures.
(D) Analyze the fossil content within the deformed rocks.

164. Which of the following best describes the role of geology in the construction of highways?
(A) To identify sources of aggregate for

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(C) Shorter wavelengths like blue light.
(D) Radio waves.

94. What is the most significant geological hazard to be considered when planning a major engineering project in a seismically active region?
(A) The presence of valuable mineral deposits.
(B) The average annual rainfall.
(C) The direction of prevailing winds.
(D) The potential for ground shaking, liquefaction, and surface faulting.

95. In remote sensing terminology, a 'sensor platform' refers to:
(A) The vehicle or medium that carries the sensor, such as a satellite or an aircraft.
(B) The computer system used to process the sensor data.
(C) The specific wavelength that the sensor detects.
(D) The ground receiving station for the data.

96. Which statement about the reflectance of water is correct?
(A) Clear water has high reflectance in the near-infrared band.
(B) Water with high sediment content generally has higher reflectance in the visible bands than clear water.
(C) Water reflectance is not affected by the presence of chlorophyll.
(D) Water appears brightest in microwave imagery.

97. An 'incorrect pair' is:
(A) Vertical Exaggeration - Perceived stretching of vertical scale
(B) Sidelap - Overlap between adjacent photos in the same flight line
(C) Fiducial Marks - Define the photo's coordinate system
(D) Drift - Lateral shift of aircraft from the flight line

98. The process of image processing that involves numerically transforming the pixel values of an image to another set of values is called:
(A) Discrete image processing
(B) Continuous image processing
(C) Optical image processing
(D) Manual image interpretation

99. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : GIS is a powerful tool for site selection for major engineering projects.
Reason (R) : GIS allows for the integration and spatial analysis of various thematic layers such as topography, geology, land use, and proximity to hazards, facilitating optimal site identification.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

100. For a reservoir to be effective, a primary geological requirement is:
(A) The presence of scenic cliffs around the water body.
(B) High permeability of the rocks in the reservoir basin to allow for groundwater recharge.
(C) A location in a highly active seismic zone.
(D) A high degree of water-tightness in the basin, provided by impermeable rock and soil.

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101. Arrange the following steps for measuring the area of a feature on an aerial photograph in the correct sequence:
1. Determine the average scale of the photograph.
2. Delineate the boundary of the feature on the photograph.
3. Calculate the area on the photograph using a planimeter or grid method.
4. Convert the photo area to ground area using the scale factor.

Choose the correct answer from the options given below:
(A) 2, 1, 3, 4
(B) 1, 2, 3, 4
(C) 2, 3, 1, 4
(D) 3, 1, 2, 4

137. The 'scale' of an aerial photograph is defined as the ratio between:
(A) The altitude of the aircraft and its ground speed.
(B) The area on the photograph and the area on the ground.
(C) A distance on the photograph and the corresponding distance on the ground.
(D) The focal length of the camera and the size of the film.

138. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : In GIS, vector data models are generally more suitable for representing discrete, well-defined features like roads, rivers, and property boundaries.
Reason (R) : The vector model uses points, lines, and polygons, which correspond well to the geometry of these distinct real-world objects.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

139. Which of the following is NOT a primary 'element of interpretation' for aerial photographs?
(A) Shape
(B) Texture
(C) Focal length
(D) Association

140. In the context of energy interaction with the Earth's surface, a material with high reflectance in the visible spectrum would appear:
(A) Bright in a panchromatic image.
(B) Dark in a panchromatic image.
(C) Transparent in a panchromatic image.
(D) Red in a panchromatic image.

141. The primary purpose of studying the 'engineering properties of rocks' before constructing a tunnel is to:
(A) Assess the rock's strength, stability, and behavior during excavation to ensure safety and design support systems.
(B) Determine the potential for finding valuable minerals during excavation.
(C) Choose the most aesthetically pleasing rock type for the tunnel portal.
(D) Estimate the time it will take for the rock to weather away.

142. Arrange the following events in the history of remote sensing in a plausible chronological order:
1. Launch of the first Landsat satellite (ERTS-1) with an MSS sensor.
2. Widespread use of aerial photography for military reconnaissance in World War I.
3. Development of high-resolution commercial satellite imagery (e.g., IKONOS).
4. Development of airborne radar systems (SLAR/SAR).

Choose the correct answer from the options given below:
(A) 2, 4, 1, 3
(B) 1, 2, 3, 4
(C) 2, 1, 4, 3
(D) 4, 2, 1, 3

143. Consider the following statements:
(i) Tilt displacement radiates from the isocenter of the photograph.
(ii) Relief displacement radiates from the nadir point of the photograph.
(iii) For a truly vertical photograph, the nadir and principal point coincide.
Which of the above statement(s) is/are correct?
(A) (i) and (ii) only
(B) (ii) and (iii) only
(C) (i) and (iii) only
(D) (i), (ii), and (iii)

144. 'Distortions' in aerial photographs refers to:
(A) Any shift in the position of an image on a photograph that alters the perspective characteristics.
(B) Intentional artistic effects added during processing.
(C) The natural color balance of the image.
(D) Errors caused by the operator during interpretation.

145. A primary application of GIS would be:
(A) The spatial analysis of geographic data for planning and decision-making.
(B) Word processing and spreadsheet analysis.
(C) The design of computer-aided drafting

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microwave spectrum, making radar sensitive to variations in soil moisture.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

111. On an aerial photograph, if the top of a tower is displaced radially outwards from the center of the photo, this is an example of:
(A) Tilt distortion
(B) Crab
(C) Vertical exaggeration
(D) Relief displacement

112. The term 'Vertical Exaggeration' in stereoscopic pairs of aerial photographs leads to:
(A) A more realistic perception of the terrain's relief.
(B) The perception of slopes and heights as being steeper and greater than they actually are.
(C) The complete flattening of the terrain in the stereo model.
(D) The reversal of topography, where valleys appear as ridges.

113. Which of the following is NOT a fundamental geometric principle of photographs?
(A) Relief displacement
(B) Tilt displacement
(C) Vertical exaggeration
(D) Chromatic aberration

114. The primary reason for having 'overlap' between successive aerial photographs in a flight line is to:
(A) Save film by taking fewer pictures.
(B) Ensure there are no gaps in coverage and to allow for stereoscopic (3D) viewing.
(C) Compensate for aircraft drift.
(D) Make the final mosaic look more artistic.

115. Application of photo geology is LEAST effective for which of the following tasks?
(A) Mapping regional structural trends.
(B) Identifying the precise in-situ stress conditions of deep bedrock.
(C) Delineating different types of surface landforms.
(D) Classifying broad lithological units based on their surface expression.

116. A LISS (Linear Imaging Self-Scanning) camera is an example of a:
(A) Whiskbroom scanner
(B) Pushbroom scanner
(C) Framing camera
(D) Radar imager

117. Consider the following statements about GIS:
(i) A GIS can be used to model the potential inundation area of a proposed reservoir.
(ii) A GIS can integrate geological map data with slope data to create a landslide susceptibility map.
(iii) A GIS is only a map-making tool and has no analytical capabilities.
Which of the above statement(s) is/are correct?
(A) (iii) only
(B) (i) and (ii) only
(C) (i) and (iii) only
(D) (i), (ii) and (iii)

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118. For building a large concrete gravity dam, the most suitable foundation rock would be:
(A) Thick, unconsolidated alluvial soil.
(B) Highly fractured and weathered shale.
(C) Sound, unweathered, high-strength rock like granite or gneiss.
(D) Cavernous limestone with active solution channels.

119. A key difference between SLAR (Side-Looking Airborne Radar) and SAR (Synthetic Aperture Radar) is that:
(A) SAR achieves higher azimuth resolution by synthesizing a larger antenna aperture.
(B) SLAR is passive while SAR is active.
(C) SLAR can penetrate clouds but SAR cannot.
(D) SLAR provides color images while SAR is black and white.

120. Match List I with List II.
List I: (Photographic Distortion/Effect)
P. Relief Displacement
Q. Tilt Displacement
R. Scale Variation
S. Crab
List II: (Cause)

1. Uneven terrain elevation
2. Combination of terrain relief and camera tilt
3. Non-vertical camera axis
4. Aircraft yaw relative to the flight line

Choose the correct answer from the options given below:
(A) P-1, Q-3, R-2, S-4
(B) P-3, Q-1, R-2, S-4
(C) P-1, Q-3, R-4, S-2
(D) P-2, Q-4, R-1, S-3

121. The reflectance of healthy vegetation is typically characterized by a peak in which portion of the electromagnetic spectrum?
(A) Blue
(B) Green
(C) Red
(D) Near Infrared (NIR)

122. Arrange the following major engineering projects in order of increasing sensitivity to underlying geological permeability.
1. A multi-story office building on a concrete slab.
2. A large water-retaining dam and reservoir.
3. A paved highway.
4. A canal for water transport.

Choose the correct answer from the options given below:
(A) 1, 3, 4, 2
(B) 2, 4, 3, 1
(C) 1, 2, 3, 4
(D) 4, 3, 1, 2

123. Which of the following statements about 'fiducial marks' on an aerial photograph is incorrect?
(A) They are used to locate the principal point of the photograph.
(B) They are typically located in the corners or on the midpoints of the sides of the photograph.
(C) They represent known ground control points.
(D) The number and position of fiducial marks are not standardized and vary by camera.

124. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A) : Photogeology and remote sensing are cost-effective and efficient tools for initial reconnaissance in mineral exploration.
Reason (R) : These techniques allow for rapid coverage of large, often inaccessible areas to identify geological structures, alteration zones, and lithological contacts that may be favorable for mineralization.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

125. The study of the engineering properties of rocks for civil engineering works is crucial for ensuring:
(A) The aesthetic harmony of the structure with nature.
(B) The safety, stability, and economic viability of the project.
(C) The structure's ability to generate its own power.
(D) That the project is completed ahead of schedule.

126. What does the study of 'aerial photography' primarily cover?
(A) The history of aviation.
(B) The fundamental concepts and terminology of acquiring and using photographs taken from an aerial platform.
(C) A detailed course on how to pilot an aircraft for surveying.
(D) The chemistry of photographic film development.

127. In the context of remote sensing, what does the 'atmosphere' do to the EMR traveling from the sun to the Earth and back to the sensor?
(A) It amplifies the energy, making the signal stronger.
(B) It scatters and absorbs the energy, modifying the signal that reaches the sensor.
(C) It has no effect on the energy.
(D) It converts all visible light to infrared energy.

128. What is a key geological consideration for the construction of a long bridge with multiple piers?

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(A) The color of the river water.
(B) The type of vegetation on the river banks.
(C) The uniformity and bearing capacity of the foundation materials at each pier location.
(D) The average temperature of the region.

129. Consider the following geological conditions:
(i) Presence of an active fault line.
(ii) Thick deposits of compressible clay.
(iii) Cavernous limestone bedrock.
Which of the above conditions would be considered a major geological hazard for the site of a nuclear power plant?
(A) (i) only
(B) (i) and (iii) only
(C) (ii) and (iii) only
(D) (i), (ii), and (iii)

130. The primary advantage of a 'mosaic' of aerial photographs is that it:
(A) Provides a 3D view of the terrain.
(B) Has a perfectly uniform scale across the entire image.
(C) Creates a continuous picture of a large area that is too big to be covered by a single photograph.
(D) Is free from all geometric distortions.

131. In remote sensing, what is a continuous image processing system"?
(A) A theoretical concept where an image is treated as a continuous function, often processed using optical methods.
(B) A system that processes images without any breaks or pauses.
(C) Another name for a digital computer that processes images.
(D) A system that can only process video feeds, not still images.

132. The term 'geomorphology' in the context of remote sensing applications refers to the study of:
(A) The Earth's magnetic field.
(B) The Earth's surface features and the processes that create and change them.
(C) The chemical composition of rocks.
(D) The distribution of ancient life forms.

133. Match List I with List II.
List I: (Remote Sensing Acronym)
P. SAR
Q. MSS
R. TIRLS
S. LISS
List II: (Full Form)
1. Multi-Spectral Scanner
2. Synthetic Aperture Radar
3. Linear Imaging Self-Scanning Sensor
4. Thermal Infra-Red Line-Scanner
Choose the correct answer from the options given below:
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-1, R-4, S-3
(C) P-2, Q-3, R-1, S-4
(D) P-4, Q-1, R-2, S-3

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134. Which of the following geological structures would be a significant concern for tunnel alignment?
(A) A gentle syncline with its axis parallel to the tunnel direction.
(B) A major fault zone with crushed rock and potential for groundwater flow.
(C) A horizontally bedded, competent sandstone formation.
(D) A small-scale igneous dike oriented perpendicular to the tunnel.

135. For geological mapping in a mid-latitude region with deciduous forests, the best season for aerial photography would likely be:
(A) Summer, when vegetation is most healthy.
(B) Late fall or early spring, when leaf cover is minimal, exposing the ground surface and rock outcrops.
(C) The peak of the rainy season, to identify water bodies.
(D) Any season, as it makes no difference to geological interpretation.

136. What is the most appropriate use of photo geology in hydrogeology studies?
(A) To directly measure the porosity of subsurface aquifers.
(B) To identify surface indicators of groundwater, such as fracture traces, vegetation anomalies, and drainage patterns.
(C) To analyze the water quality for dissolved minerals.
(D) To pinpoint the exact depth to drill for water.

(D) A is false but R is true.

84. In GIS, what kind of analysis would be used to find all areas within 500 meters of a river?
(A) Overlay analysis
(B) Network analysis
(C) Reclassification
(D) Proximity analysis (Buffering)

85. Which of the following remote sensing systems has the best capability to see" through cloud cover?
(A) LISS-III
(B) Landsat TM (Thematic Mapper)
(C) Microwave Radar (SAR)
(D) High-resolution panchromatic camera

86. When interpreting lithology from aerial photographs, a massive, uniform, and light-toned appearance with a dendritic drainage pattern might suggest:
(A) Folded sedimentary rocks
(B) A granite intrusion
(C) A basaltic lava flow
(D) A highly fractured limestone

87. Which of the following is NOT a type of dam?
(A) Gravity Dam
(B) Arch Dam
(C) Buttress Dam
(D) Floating Dam

88. Consider the following statements about relief displacement:
(i) It is directed radially outwards from the principal point for points above the datum.
(ii) Its magnitude increases with increasing distance from the principal point.
(iii) It is the primary phenomenon that allows for stereoscopic 3D viewing.
Which of the above statement(s) is/are correct?
(A) (i) and (ii) only
(B) (ii) and (iii) only
(C) (i) and (iii) only
(D) (i), (ii) and (iii)

89. Taking measurements of height from aerial photographs requires:
(A) A single vertical photograph and knowledge of the sun angle.
(B) A single oblique photograph.
(C) A pair of overlapping photographs (a stereo pair) and a device to measure parallax.
(D) A thermal infrared image.

90. Match List I with List II.
List I: (EMR Region)
P. Visible
Q. Near Infrared (NIR)
R. Thermal Infrared (TIR)
S. Microwave
List II: (Typical Application)
1. Soil moisture estimation, penetration of clouds.
2. Assessing vegetation health and biomass.
3. Mapping land cover in a way similar to human vision.
4. Detecting heat, such as forest fires or urban heat islands.
Choose the correct answer from the options given below:
(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-2, R-4, S-1
(C) P-3, Q-4, R-1, S-2
(D) P-2, Q-3, R-4, S-1

91. Which of the following is a key advantage of multi-spectral photography?
(A) It can be performed at night without an artificial light source.
(B) It is entirely unaffected by atmospheric conditions.
(C) It automatically produces a perfectly scaled and geometrically correct map.
(D) It provides information beyond what the human eye can see, aiding in material differentiation.

92. The lining of a tunnel" serves all of the following purposes EXCEPT:
(A) Preventing the inflow of groundwater.
(B) Increasing the permeability of the surrounding rock mass.
(C) Supporting the weight of the surrounding rock and preventing rock falls.
(D) Providing a smooth interior surface for ventilation and traffic.

93. The phenomenon of Rayleigh scattering in the atmosphere is most pronounced for:
(A) Longer wavelengths like infrared.
(B) Microwaves.

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(CAD) models for mechanical parts.
(D) The creation of photorealistic animations.

146. A multi-spectral scanner (MSS) like the one on early Landsat satellites is a 'whiskbroom' scanner. This means it:
(A) Scans the entire scene at once with a linear array of detectors.
(B) Uses a rotating mirror to scan the scene line by line, perpendicular to the direction of flight.
(C) Is a passive sensor that does not require a mirror.
(D) Scans the scene using a beam of microwaves.

147. Which pair, related to aerial survey planning, is correctly matched?
(A) Flight Plan - Specifies the required image scale and coverage.
(B) Overlap - Overlap between adjacent flight lines.
(C) Sidelap - Overlap between consecutive photos in a single flight line.
(D) Crab - The intentional tilt of the camera.

148. The study of 'lithology' using remote sensing relies on the principle that:
(A) Different rock types often have different spectral reflectance characteristics and weathering patterns.
(B) All rocks look identical from space.
(C) The sensor can directly measure the chemical composition of the rock.
(D) Only igneous rocks can be identified using remote sensing.

149. The ability of a sensor to detect small differences in electromagnetic energy is its:
(A) Spatial resolution
(B) Spectral resolution
(C) Temporal resolution
(D) Radiometric resolution

150. Match List I with List II.
List I: (Dam Type)
P. Gravity Dam
Q. Arch Dam
R. Buttress Dam
S. Embankment Dam
List II: (Primary Resisting Force/Mechanism)
1. Horizontal arch action transferring load to abutments.
2. Shear strength and weight of the fill material.
3. Massive weight of the concrete or masonry structure.
4. Series of supports on the downstream face.
Choose the correct answer from the options given below:
(A) P-1, Q-3, R-2, S-4
(B) P-3, Q-1, R-4, S-2
(C) P-3, Q-4, R-1, S-2
(D) P-2, Q-1, R-4, S-3

151. Why is geology important for the construction of canals?
(A) To assess soil and rock permeability to prevent seepage losses, and to evaluate slope stability for cuttings.
(B) To ensure the water in the canal is of drinkable quality.
(C) To locate sources of decorative stone for the canal banks.
(D) To determine the best locations for fishing and recreational activities.

152. Which of the following is NOT an 'active sensor'?
(A) SAR (Synthetic Aperture Radar)
(B) SLAR (Side-Looking Airborne Radar)
(C) Lidar (Light Detection and Ranging)
(D) LISS (Linear Imaging Self-Scanning Sensor)

153. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : The interpretation of aerial photographs is enhanced by stereoscopic viewing.
Reason (R) : Stereoscopic viewing of overlapping pairs of photographs creates a three-dimensional model of the terrain, which aids in the identification of landforms, geological structures, and drainage patterns.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

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102. What is the fundamental principle behind using aerial photographs for studying structural features like faults?
(A) Faults emit a unique type of electromagnetic radiation.
(B) Faults often manifest as linear topographic features, offsets in rock layers, or alignments of vegetation and drainage.
(C) The camera lens is able to penetrate the ground and image the fault plane directly.
(D) Faults can only be seen on thermal infrared images.

103. Which of the following is a typical characteristic of a passive remote sensing system?
(A) It relies on detecting solar energy reflected from the Earth's surface.
(B) It emits a strong pulse of energy and records the return signal.
(C) It can function identically during both day and night for all wavelengths.
(D) It is immune to atmospheric effects like clouds and haze.

104. Consider the following statements regarding the engineering properties of rocks:
(i) Porosity is the measure of void spaces in a rock and is a measure of how much fluid it can store.
(ii) Permeability is the measure of the ability of a material to allow fluids to pass through it.
(iii) A rock can be highly porous but have very low permeability if the pores are not interconnected.
Which of the above statement(s) is/are correct?
(A) (i) and (ii) only
(B) (ii) and (iii) only
(C) (i) and (iii) only
(D) (i), (ii) and (iii)

105. When analyzing a highway route, what geological issue is of major concern in areas where the road is built on an embankment (fill)?
(A) The bearing capacity and potential for settlement of the underlying foundation material.
(B) The aesthetic appearance of the fill material.
(C) The color of the asphalt to be used.
(D) The maximum speed limit on the highway.

106. Match List I with List II.
List I: (Project Feature)
P. Foundation of a bridge pier
Q. Sides of a highway cutting
R. Area flooded by a dam
S. Lining of a water canal
List II: (Geological Term)
1. Slope stability
2. Bearing capacity
3. Permeability
4. Reservoir tightness
Choose the correct answer from the options given below:
(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-4, R-1, S-3
(D) P-4, Q-1, R-2, S-3

107. The 'purpose' of an aerial photography mission is a key controlling factor because it dictates:
(A) The type of aircraft used.
(B) The required scale, which in turn determines flying height and camera choice.
(C) The number of pilots on the aircraft.
(D) The location of the nearest airport.

108. Which component of a GIS is responsible for storing non-spatial information about features, such as the name of a river or the type of a road?
(A) The attribute table
(B) The spatial data layer
(C) The map projection file
(D) The symbology library

109. What is a discrete image processing system"?
(A) A computer-based system that treats an image as a grid of pixels (a matrix of numbers) and manipulates these numbers.
(B) A system that processes photographs taken on film.
(C) A system that can only process images discreetly and not in public.
(D) A system that uses lenses and filters to process an image optically.

110. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : Microwave remote sensing is highly valuable for hydrogeological studies.
Reason (R) : The dielectric properties of water cause it to have a strong response in the

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construction and to assess the stability of slopes in cuts and the foundation for fills and bridges.
(B) To determine the optimal number of lanes for the highway.
(C) To design the road signs and lighting.
(D) To predict traffic flow patterns.

165. Match List I with List II.
List I: (GIS Function)
P. Data Capture
Q. Spatial Analysis
R. Data Management
S. Data Display
List II: (Example)
1. Creating a map showing landslide risk zones.
2. Digitizing a paper geological map.
3. Performing an overlay of soil and slope layers.
4. Storing geological data in a structured database with spatial indexing.
Choose the correct answer from the options given below:
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-3, R-4, S-1
(C) P-2, Q-4, R-3, S-1
(D) P-3, Q-1, R-4, S-2

166. A sensor platform that maintains a fixed position relative to the Earth's surface by orbiting at an altitude of approximately 36,000 km over the equator is known as a:
(A) Sun-synchronous satellite
(B) Geostationary satellite
(C) Low Earth orbit (LEO) satellite
(D) Unmanned aerial vehicle (UAV)

167. An uncontrolled mosaic is an assembly of uncorrected aerial photographs. Its main disadvantage is:
(A) It contains significant geometric distortions and scale variations, making it unsuitable for accurate measurements.
(B) It is very expensive to produce.
(C) It takes a long time to assemble.
(D) It can only be viewed in 3D.

168. In remote sensing, the term 'imaging sensor' implies that the sensor:
(A) Can only detect energy but not record its spatial distribution.
(B) Creates a picture-like representation of the scene being observed.
(C) Only works in the microwave part of the spectrum.
(D) Is a type of passive sensor exclusively.

169. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : Geological considerations are paramount in the selection of a dam site.
Reason (R) : The presence of weak, permeable, or highly fractured rock in the foundation or abutments can lead to dam failure or excessive leakage from the reservoir.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

170. Which of the following is NOT a form of electromagnetic radiation (EMR) used in remote sensing?
(A) Visible light
(B) Microwaves
(C) Thermal infrared
(D) Sonic waves

171. A primary reason for requiring 'background knowledge' in photo interpretation is that:
(A) Similar features on a photo can have different geological explanations depending on the regional context.
(B) It allows the interpreter to guess the answer without looking at the photo.
(C) It is a requirement for purchasing aerial photographs.
(D) It helps in focusing the stereoscope correctly.

172. The choice of a 'flight plan' for an aerial survey is NOT influenced by:
(A) The desired scale of the photos.
(B) The geographical boundaries of the area to be surveyed.
(C) The brand of GPS receiver in the pilot's personal phone.
(D) The required overlap and sidelap.

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225. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : GIS provides a framework for integrating and analyzing diverse datasets for civil engineering site selection.
Reason (R) : A GIS can only display one map at a time and cannot perform analysis between different data types.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

226. 'Energy interaction with the atmosphere' includes all of the following processes EXCEPT:
(A) Scattering
(B) Absorption
(C) Reflection
(D) Photosynthesis

227. When building a highway through a hilly region, a major geological concern is:
(A) The stability of the slopes created by road cuts.
(B) The scenic quality of the views from the road.
(C) The availability of rest stops.
(D) The color of the native soil.

228. Consider the following parameters for an aerial survey:
(i) Scale of the photos
(ii) Overlap between photos
(iii) The time of day for the flight
Which of the above must be specified in a flight plan?
(A) (i) only
(B) (i) and (ii) only
(C) (ii) and (iii) only
(D) (i), (ii), and (iii)

229. The term 'lithology' in the context of photogeology refers to:
(A) The study of literature about geology.
(B) The study of light.
(C) The general physical characteristics of a rock or rock unit.
(D) The process of printing photographs.

230. 'Vertical exaggeration' in a stereo-model is generally considered advantageous for geological interpretation because:
(A) It accentuates subtle topographic features like low-angle dips of strata, making them easier to see.
(B) It makes the 3D model perfectly accurate in scale.
(C) It removes the need for ground verification.
(D) It corrects for all lens distortion.

231. The main difference between a 'mosaic' and a 'photo-geologic map' is:
(A) A mosaic is an assembly of photos, while a photo-geologic map is an interpretation of geology drawn from the photos.
(B) A mosaic is always a perfect map, while a photo-geologic map has distortions.
(C) Mosaics are for engineers, while photo-geologic maps are for geologists.
(D) There is no difference.

232. An arch dam is most suitable for:
(A) A wide, flat valley with weak foundation rock.
(B) A location where the only available material is earth and rock fill.
(C) An area with high seismicity.
(D) A narrow canyon with strong rock in the abutments (sides).

233. The reflectance of vegetation is unique in that it shows a sharp increase in which part of the spectrum?
(A) Ultraviolet
(B) Blue
(C) Near-infrared
(D) Green

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234. In GIS, which data format would be best for representing a river network?
(A) Vector (lines)
(B) Raster
(C) Attribute table
(D) Point cloud

235. Arrange the following forms of EMR in order of INCREASING wavelength:
1. Microwave
2. Thermal Infrared
3. Visible Light

4. Emitted thermal energy detection

Choose the correct answer from the options given below:

(A) P-3, Q-1, R-2, S-4
(B) P-1, Q-3, R-2, S-4
(C) P-3, Q-2, R-1, S-4
(D) P-4, Q-1, R-2, S-3

182. Which of the following remote sensing technologies would be most effective for mapping subtle topographic features beneath a dense forest canopy?

(A) High-resolution visible light photography
(B) Thermal Infrared (TIR) imagery
(C) Multi-spectral imagery (LISS)
(D) Airborne Lidar (Light Detection and Ranging) or SAR

183. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A) : Karstic limestone terrain, characterized by sinkholes and caverns, is a particularly hazardous foundation for a dam and reservoir.

Reason (R) : The interconnected solution channels in karstic terrain can lead to catastrophic leakage from the reservoir and instability of the dam's foundation.

(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

184. In the interpretation of aerial photographs, 'texture' refers to the:

(A) The overall shape of a feature.
(B) The frequency of tonal change and arrangement of individual features too small to be discerned individually, creating a characteristic appearance (e.g., smooth, coarse, mottled).
(C) The feeling of the glossy surface of the photographic paper.
(D) The relative size of an object compared to other objects in the scene.

185. The difference between `Image Processing Basics`, `Continuous Image Processing`, and `Discrete Image Processing System` is best summarized as:

(A) Basics cover the fundamentals, while `Continuous` refers to optical processing and `Discrete` refers to digital processing of images as pixels.
(B) They are three unrelated fields of study.
(C) `Continuous` processing is for video, `Discrete` is for still photos, and basics are the user manual.
(D) `Discrete` systems are small and portable, while `Continuous` systems are large and stationary.

186. Why is knowledge of the engineering properties of rocks essential for highway construction?

(A) To ensure the stability of cuts and fills and provide a solid foundation for bridges and roadbeds.
(B) To decide the brand of cars that can use the highway.
(C) To choose a scenic route.
(D) To predict the amount of traffic congestion.

187. Which of the following statements is incorrect regarding the application of remote sensing?

(A) It can be used to monitor changes in land use and land cover over time.
(B) It can directly measure the age of rock formations in millions of years.
(C) It is useful for mapping the extent of floods and forest fires.
(D) It can be used to identify potential groundwater zones by mapping surface indicators.

188. Consider the following factors for planning an aerial photography flight:

(i) The scale of the photograph required.
(ii) The area to be covered.
(iii) The time and season for optimal ground visibility.

Which of the above statement(s) is/are correct?

(A) (i) only
(B) (i) and (ii) only
(C) (ii) and (iii) only
(D) (i), (ii), and (iii)

189. A sensor that detects emitted thermal energy from the Earth's surface is operating in which part of the spectrum?

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(B) An error in the photographic process that makes objects appear taller.
(C) A deliberate misrepresentation of height data.
(D) The flattening of all topographic features in the 3D view.

208. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : The season in which aerial photography is conducted is an important consideration.
Reason (R) : For geological purposes, photography in seasons with low vegetation cover and optimal sun angle for shadow enhancement is often preferred.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

209. The reflectance of minerals" is a key concept because:
(A) Different minerals have characteristic absorption and reflection features at different wavelengths, which can be used to identify them.
(B) All minerals reflect light in exactly the same way.
(C) The reflectance of a mineral determines its economic value.
(D) Only shiny minerals have reflectance.

210. Which of the following is the most critical geological consideration for tunneling?
(A) The color of the rock to be excavated.
(B) The rock type, its structural condition (faults, joints), groundwater conditions, and in-situ stresses.
(C) The surface vegetation above the tunnel path.
(D) The air temperature at the tunnel portal.

211. In remote sensing, what is a sensor platform"?
(A) The specific type of camera or scanner used.
(B) The ground station that receives the data.
(C) The aircraft, satellite, or other vehicle on which the sensor is mounted.
(D) The software used to analyze the sensor data.

212. What distinguishes multi-spectral photography from standard color photography?
(A) Multi-spectral uses black and white film only.
(B) Multi-spectral photography captures data in specific, often narrow, wavelength bands, including those outside the visible spectrum (like NIR).
(C) Multi-spectral photography is only taken from satellites.
(D) Multi-spectral photography cannot be used to create a color image.

213. Consider the following statements about GIS applications:
(i) A GIS can be used to analyze the spatial relationship between earthquake epicenters and known faults.
(ii) A GIS can help plan the optimal route for a new highway by considering factors like slope, land ownership, and environmental constraints.
(iii) A GIS can create a landslide hazard map by combining data on slope, geology, rainfall, and land cover.
Which of the above statement(s) is/are correct?
(A) (i) and (ii) only
(B) (ii) and (iii) only
(C) (i) and (iii) only
(D) (i), (ii), and (iii)

214. The geometric principle of 'relief displacement' is useful because it:
(A) Allows for the calculation of the height of objects from photographs.
(B) Completely eliminates all distortions from the photograph.
(C) Is the sole cause of vertical exaggeration.
(D) Corrects for the tilt of the camera.

215. Which of the following statements about active and passive sensors is correct?
(A) A camera with a flash is an example of a passive sensor.
(B) A thermal scanner detecting heat emitted from a volcano is an example of an active sensor.
(C) A radar system (like SAR) is an active sensor

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199. What does 'SAR' stand for in the context of remote sensing?
(A) Scientific and Academic Radar
(B) Satellite-borne Atmospheric Radiometer
(C) Spectral Analysis of Reflectance
(D) Synthetic Aperture Radar

200. Consider the following regarding the lining of a tunnel:
(i) It helps to prevent water from seeping into the tunnel.
(ii) It provides structural support to the tunnel, especially in weak rock.
(iii) It creates a smooth surface which can improve ventilation and safety.
Which of the above are functions of tunnel lining?
(A) (i) and (ii) only
(B) (ii) and (iii) only
(C) (i) and (iii) only
(D) (i), (ii), and (iii)

201. Match List I with List II.
List I: (Aerial Photo Parameter)
P. Drift
Q. Crab
R. Overlap
S. Sidelap
List II: (Definition)
1. Rotation of the aircraft causing photos to be skewed.
2. The amount by which one photo covers the same area as the next photo in the same flight line.
3. The lateral shift of the aircraft from the planned flight line.
4. The amount by which one flight line covers the area of an adjacent flight line.
Choose the correct answer from the options given below:
(A) P-3, Q-1, R-2, S-4
(B) P-1, Q-3, R-2, S-4
(C) P-3, Q-1, R-4, S-2
(D) P-4, Q-2, R-1, S-3

202. The concept of Energy Interaction with Earth surface and atmosphere" is central to remote sensing because:
(A) The signal recorded by the sensor is a product of these complex interactions, and understanding them is key to interpretation.
(B) The sensor's characteristics are the only thing that matters.
(C) The Earth's surface is a perfect reflector.
(D) The atmosphere is completely transparent to all forms of EMR.

203. Which of the following is NOT a good geological condition for a reservoir site?
(A) A wide, deep basin to maximize storage volume.
(B) A narrow, steep outlet that is suitable for dam construction.
(C) A foundation of impermeable bedrock like shale or massive granite.
(D) An underlying geology of highly permeable sandstone or cavernous limestone.

204. Basic aerial photography studies would cover the difference between:
(A) A digital camera and a film camera.
(B) A still camera and a video camera.
(C) Vertical photographs and oblique photographs.
(D) Color photography and black-and-white photography.

205. The primary advantage of microwave imagery (Radar) over optical imagery is its ability to:
(A) Provide images in true color.
(B) Achieve much higher spatial resolution.
(C) Penetrate clouds, haze, and light rain, and to operate day or night.
(D) Directly measure the temperature of the ground surface.

206. A GIS is particularly useful in hydrogeological studies for:
(A) Performing chemical analysis of water samples.
(B) Integrating various spatial datasets (geology, slope, land use, rainfall) to delineate groundwater potential zones.
(C) The physical drilling of borewells.
(D) Designing the pumps for water extraction.

207. What does the term Vertical Exaggeration" signify in the context of stereoscopic photo-interpretation?
(A) The phenomenon where the vertical scale of the stereo model appears stretched relative to the horizontal scale.

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canal.
(B) The aesthetic quality of the bridges crossing the canal.
(C) The political jurisdiction of the water source.
(D) The permeability of the soil and rock along the route, which affects water loss.

245. Consider the following statements about remote sensing sensors:
(i) A LISS camera is a passive sensor.
(ii) A SAR system is an active sensor.
(iii) A thermal scanner can operate at night.
Which of the above statement(s) is/are correct?
(A) (i) only
(B) (i) and (ii) only
(C) (ii) and (iii) only
(D) (i), (ii), and (iii)

246. The term 'fiducial marks' refers to:
(A) Reference marks on an aerial photograph, used to define the internal geometry of the photo.
(B) Scratches on the film caused by mishandling.
(C) Points of known location on the ground.
(D) The corners of the photographic print.

247. The primary reason for using photogeology and remote sensing in the study of 'structural features' is to:
(A) Identify and map the surface expression of features like faults and folds over large areas.
(B) Directly measure the stress and strain in rocks.
(C) Determine the exact age of tectonic events.
(D) Analyze the geochemistry of fault gouge from a distance.

248. The scale of a vertical aerial photograph over mountainous terrain:
(A) Is constant across the entire photograph.
(B) Varies depending on the color of the ground.
(C) Is determined solely by the speed of the aircraft.
(D) Varies depending on the elevation of the ground, being larger for higher ground.

249. Which of the following is NOT one of the 'Elements of Interpretation of Aerial Photographs'?
(A) Price/Cost
(B) Texture
(C) Pattern
(D) Tone/Color

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250. The engineering geology investigation for a tunnel is most concerned with:
(A) The properties of the rock and soil to be excavated, groundwater conditions, and potential for instability.
(B) The scenic view from the tunnel portals.
(C) The names of the towns at either end of the tunnel.
(D) The type of lighting to be installed inside the tunnel.

251. A key application of a Thermal Infra-Red Line-Scanner (TIRLS) is:
(A) Mapping surface temperature variations, useful for detecting forest fires or geothermal activity.
(B) Measuring the height of trees.
(C) Penetrating cloud cover to image the ground.
(D) Creating a 3D model of the terrain.

252. The term 'passive sensors' in remote sensing refers to sensors that:
(A) Are not powered by electricity.
(B) Detect naturally available energy (like reflected sunlight or emitted heat).
(C) Can only be used when the satellite is not moving.
(D) Provide their own source of energy for illumination.

253. Why would a civil engineer be concerned with the 'engineering properties of rocks'?
(A) To decide on a color scheme for a project.
(B) To find fossils for a museum.
(C) To practice their rock climbing skills.
(D) To understand how a rock will behave under the stress of a foundation or in the wall of a tunnel.

254. A primary function of a Geographic Information System (GIS) is to:
(A) Capture, store, analyze, and display geographically referenced information.
(B) Process financial transactions for engineering projects.

because it provides its own illumination.
(D) Passive sensors can collect data under any weather conditions.

216. In the context of aerial photography, 'scale' is primarily determined by:
(A) The aircraft's flying height above the ground and the camera's focal length.
(B) The speed of the aircraft and the shutter speed of the camera.
(C) The time of day and the season of the year.
(D) The amount of overlap and sidelap between photos.

217. When remote sensing is used for hydrogeological studies, it is most effective at:
(A) Directly sampling the chemical quality of deep groundwater.
(B) Identifying surface features that are indirect indicators of groundwater presence.
(C) Measuring the precise flow rate of underground aquifers.
(D) Determining the age of the water in an aquifer.

218. The engineering properties of rocks, such as strength and permeability, are a major focus in engineering geology because they:
(A) Determine the aesthetic value of a building stone.
(B) Control how the ground will behave when a load is placed upon it or a tunnel is excavated through it.
(C) Are only relevant for projects involving dams.
(D) Can be easily changed by civil engineers.

219. The 'lining of a tunnel' would be most substantial and critical when tunneling through:
(A) A massive, unjointed granite body.
(B) A dry, well-cemented sandstone.
(C) A solid, stable limestone formation.
(D) A squeezing ground" consisting of wet, sheared shale under high pressure.

220. Match List I with List II.
List I: (Sensor)
P. Photographic Camera
Q. SLAR
R. LISS
S. TIRLS
List II: (Type/Primary Characteristic)
1. Active microwave sensor
2. Passive sensor detecting emitted heat
3. Passive optical-mechanical scanner (whiskbroom or pushbroom)
4. Passive sensor using a lens to focus light on film/detector
Choose the correct answer from the options given below:
(A) P-4, Q-1, R-3, S-2
(B) P-1, Q-4, R-3, S-2
(C) P-4, Q-3, R-1, S-2
(D) P-2, Q-1, R-4, S-3

221. Which statement incorrectly describes a factor affecting aerial photographs?
(A) Low sun angle can enhance micro-relief through shadowing.
(B) The political affiliation of the pilot influences the photo's scale.
(C) Heavy vegetation cover can obscure underlying geology.
(D) Atmospheric haze reduces image contrast and clarity.

222. For which major engineering project is 'reservoir tightness' the most critical geological consideration?
(A) A highway interchange.
(B) A skyscraper.
(C) A long-span bridge.
(D) A dam and reservoir.

223. What is a Discrete Image Processing System" primarily concerned with?
(A) Processing images using optical lenses and filters.
(B) The manipulation of digital images represented as a grid of pixels on a computer.
(C) The theory of continuous mathematical functions representing images.
(D) The manual retouching of photographic prints.

224. Which of the following is a primary 'element of interpretation' used to identify objects on an aerial photograph?
(A) Price
(B) Weight
(C) Shape
(D) Smell

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173. What is a significant geological issue for bridge construction?
(A) The color of the paint to be used on the bridge.
(B) The bearing capacity of the foundation material under the abutments and piers.
(C) The amount of bird traffic in the area.
(D) The name of the river being crossed.

174. Consider the following:
(i) LISS
(ii) SAR
(iii) MSS
Which of the above are imaging sensors used in remote sensing?
(A) (i) and (ii) only
(B) (ii) and (iii) only
(C) (i) and (iii) only
(D) (i), (ii), and (iii)

175. The displacement of an object's image on a photograph due to camera tilt is known as:
(A) Tilt displacement
(B) Relief displacement
(C) Parallax
(D) Vertical exaggeration

176. Which of these is an example of a GIS application in engineering geology?
(A) Creating a 3D rendering of a building's interior.
(B) Overlaying a map of active faults with a map of proposed infrastructure to identify high-risk zones.
(C) Running a financial model for a construction project.
(D) Writing a report on the engineering properties of basalt.

177. A key factor affecting an aerial photograph is the 'time' of day it is taken. Low sun angles are sometimes preferred because:
(A) They create long shadows that enhance the subtle expression of topography and linear features.
(B) The air is cooler, which improves engine performance.
(C) There is less air traffic in the early morning or late afternoon.
(D) The light is brighter, allowing for faster shutter speeds.

178. Arrange the following steps in creating a simple photo-geologic map in the correct sequence:
1. Delineate geological features (contacts, structures, landforms) on the photos.
2. Acquire stereoscopic aerial photo coverage of the area.
3. Perform field checks to verify interpretations and collect rock samples.
4. Transfer the interpreted linework from the photos to a basemap.

Choose the correct answer from the options given below:
(A) 1, 2, 3, 4
(B) 2, 1, 4, 3
(C) 2, 3, 1, 4
(D) 3, 2, 4, 1

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179. The purpose of 'tunnel lining' is multifaceted. Which of the following is its primary structural function?
(A) To support the rock mass and prevent collapse into the tunnel opening.
(B) To provide a surface for painting murals.
(C) To act as a conduit for electrical wiring.
(D) To improve the tunnel's aerodynamic profile.

180. A 'sun-synchronous' orbit is advantageous for many Earth observation satellites because:
(A) It ensures that images of any given location are always acquired at approximately the same local solar time, providing consistent illumination conditions.
(B) It allows the satellite to remain stationary over a single point on the equator.
(C) It is the highest possible orbit, providing the widest field of view.
(D) It is an orbit that is always in sunlight, allowing the satellite to generate solar power continuously.

181. Match List I with List II.
List I: (Term)
P. GIS
Q. SAR
R. Photogrammetry
S. TIRLS
List II: (Associated Concept)
1. Active microwave imaging
2. Measurement from photographs
3. Spatial data analysis

4. Near Infrared

Choose the correct answer from the options given below:

(A) 3, 4, 2, 1
(B) 1, 2, 4, 3
(C) 3, 2, 4, 1
(D) 4, 3, 2, 1

236. A key engineering property of rock for tunnel design is its 'stand-up time'. This refers to:

(A) How long the rock can stand being exposed to sunlight.
(B) The time it takes to drill a blast hole in the rock.
(C) How long the rock has existed geologically.
(D) The length of time an unsupported excavation in the rock will remain stable before it starts to collapse.

237. Which of the following is an example of an 'active' sensor?

(A) A human eye.
(B) A photographic film camera using sunlight.
(C) A thermal infrared scanner measuring ground heat.
(D) A Synthetic Aperture Radar (SAR) system.

238. 'Sidelap' is required in aerial photography to:

(A) Ensure the pilot stays on the correct flight line.
(B) Ensure there are no gaps in coverage between adjacent flight lines and to tie the lines together.
(C) Create the 3D effect in a single flight line.
(D) Compensate for the crab of the aircraft.

239. The 'importance of geology in civil engineering' stems from the fact that:

(A) Most civil engineers have a secondary degree in geology.
(B) Geologists are solely responsible for obtaining construction permits.
(C) Construction materials are billed based on their geological name.
(D) All structures are founded on the earth, and the properties of the earth materials dictate the design and safety of the structure.

240. Match List I with List II.

List I: (Term)

P. Geomorphology
Q. Lithology
R. Hydrogeology
S. Structural Geology

List II: (Brief Description)

1. The study of rock types.
2. The study of landforms.
3. The study of folds and faults.
4. The study of groundwater.

Choose the correct answer from the options given below:

(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-1, R-4, S-3
(C) P-2, Q-3, R-1, S-4
(D) P-4, Q-1, R-2, S-3

241. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A) : Remote sensing can be a valuable tool in monitoring and assessing natural hazards.

Reason (R) : Satellite imagery can be used to map the extent of areas affected by floods, wildfires, and volcanic eruptions, often more quickly and safely than ground-based methods.

(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

242. In a GIS, what kind of data is represented by a grid of cells, where each cell has a value (e.g., elevation)?

(A) Vector data
(B) Raster data
(C) Attribute data
(D) Metadata

243. The displacement of the top of a utility pole farther from the center of a vertical photo than its base is an example of:

(A) Relief displacement
(B) Atmospheric distortion
(C) Film shrinkage
(D) Lens flare

244. A major geological consideration for the construction of a large canal is:

(A) The potential for fish to migrate along the

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(A) Visible
(B) Near Infrared
(C) Thermal Infrared
(D) Ultraviolet

190. What is the main purpose of geological consideration in major engineering projects"?
(A) To increase the cost and duration of the projects.
(B) To ensure that the project is geologically themed.
(C) To identify and mitigate geological hazards, ensuring the project's safety, stability, and long-term performance.
(D) To provide jobs for geologists.

191. In aerial photography, the term 'nadir' refers to:
(A) The highest point in the photographed area.
(B) The point on the ground directly beneath the camera lens at the moment of exposure.
(C) The center point of the photograph.
(D) The point where the camera was manufactured.

192. Which type of remote sensing is based on detecting energy that is naturally reflected or emitted from the Earth's surface?
(A) Passive remote sensing
(B) Active remote sensing
(C) Radar remote sensing
(D) Lidar remote sensing

193. The difference between an aerial photograph and a map is that:
(A) A photograph has a uniform scale, whereas a map does not.
(B) A map is always in color, whereas a photograph is always black and white.
(C) There is no fundamental difference; the terms are interchangeable.
(D) A photograph shows a perspective view with geometric distortions, whereas a map is an orthographic projection with a uniform scale.

194. In the context of a GIS, what is a 'layer'?
(A) A collection of geographic data of the same type or theme, such as a layer for roads, a layer for rivers, and a layer for elevation.
(B) A single pixel in a raster image.
(C) The transparent plastic sheet used for manual map overlays.
(D) The physical thickness of a printed map.

195. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : Healthy green vegetation appears very bright in near-infrared (NIR) imagery.
Reason (R) : The cellular structure of healthy leaves reflects a large proportion of incident NIR energy.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

196. The study of 'Geomorphology' using aerial photographs and remote sensing images primarily involves the analysis of:
(A) Landforms and the processes that shape the Earth's surface.
(B) The chemical composition of atmospheric gases.
(C) The internal structure of the Earth's core.
(D) The biodiversity of plant species.

197. Which of the following is a critical geological factor for selecting a dam site?
(A) The presence of strong, impermeable rock at the foundation and abutments.
(B) The aesthetic view from the crest of the dam.
(C) The proximity to a major city for tourism purposes.
(D) The local folklore about the river.

198. The main difference between 'relief displacement' and 'tilt displacement' is:
(A) Relief displacement is caused by terrain elevation, while tilt displacement is caused by the camera's orientation.
(B) Relief displacement only affects tall objects, while tilt displacement affects everything.
(C) There is no difference; they are the same phenomenon.
(D) Tilt displacement is vertical, while relief displacement is horizontal.

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(C) Design the mechanical components of a satellite.
(D) Write and compile computer code.

255. In aerial photography for geological interpretation, why is a low sun angle often desirable?
(A) It reduces the overall brightness, making the photo easier to look at.
(B) It creates long shadows that accentuate subtle topographic relief, which may be controlled by underlying geology.
(C) The air is generally less turbulent at dawn and dusk.
(D) It ensures that the shadows are very short, so they don't hide anything.

256. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : A perfectly vertical aerial photograph of a non-flat area will still contain geometric distortions.
Reason (R) : Relief displacement, a form of geometric distortion, is caused by variations in terrain elevation and is inherent in perspective projections like photographs.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

257. Which of the following is a key geological consideration for the location of a bridge?
(A) The strength and stability of the ground material that will support the bridge's foundations (piers and abutments).
(B) The proximity of the bridge to a scenic waterfall.
(C) The local wind patterns.
(D) The species of fish in the river.

258. The main advantage of 'multi-spectral photography' over panchromatic is that it:
(A) Provides information in different parts of the spectrum, allowing for better differentiation of materials like vegetation, soil, and rock types.
(B) Is cheaper and quicker to acquire.
(C) Has a much higher spatial resolution.
(D) Is free from atmospheric interference.

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259. What does the term 'sidelap' refer to in the context of a flight plan for aerial photography?
(A) The overlap between two consecutive photographs in the same flight line.
(B) The overlap between adjacent, parallel flight lines.
(C) The area on the side of the photo that is blurry.
(D) The tendency of the aircraft to slide sideways in the wind.

260. Consider the following datasets:
(i) A map of bedrock geology.
(ii) A map showing the locations of recent landslides.
(iii) A map of slope steepness derived from a DEM.
Which of the above statement(s) is/are correct regarding tasks a GIS can perform?
(A) Determining the age of the bedrock.
(B) Writing a report about the landslides.
(C) Analyzing the spatial correlation between landslide locations, geology, and steep slopes.
(D) Printing each map on a separate piece of paper.

261. The process of arranging aerial photographs into a single large picture of an area is called creating a:
(A) Mosaic
(B) Geologic map
(C) Topographic map
(D) Flight plan

262. Which of the following remote sensors works by transmitting a pulse of its own energy and recording the reflected signal?
(A) SAR (radar)
(B) LISS camera
(C) Thermal scanner
(D) Photographic film

263. A dam that relies on its sheer weight to resist the force of the water is called a:
(A) Arch dam
(B) Buttress dam
(C) Gravity dam

detect emitted thermal energy, the assertion that they can all operate effectively at any time is scientifically false.

18. (A) Rayleigh scattering affects longer wavelengths more significantly than shorter wavelengths.
Rayleigh scattering occurs when electromagnetic radiation interacts with particles much smaller than its wavelength. This process affects shorter wavelengths, such as blue light, much more intensely than longer wavelengths. This is why the sky appears blue and why haze is more problematic in the visible spectrum than in the infrared, making the statement about longer wavelengths being affected incorrect.

19. (C) The presence of competent rock with minimal structural defects like faults and joints.
Tunneling requires competent rock that can maintain stability during and after excavation. Engineers must identify structural defects such as faults, joints, and shears, which can lead to rock falls or groundwater inflow. Minimizing these hazards is essential for the safety of workers and the long-term integrity of the tunnel structure, prioritizing geological stability over aesthetics or proximity.

20. (D) A system designed to capture, store, manipulate, analyze, manage, and present all types of geographical data.
A Geographic Information System is a comprehensive framework designed to handle spatial data. It integrates hardware, software, and data to capture, manage, analyze, and visualize all types of geographically referenced information. Unlike simple mapping tools or GPS units, GIS allows for complex spatial analysis, such as overlaying different thematic layers to solve complex engineering and environmental problems.

21. (D) (i), (ii) and (iii)
Systematic aerial photography requires specific flight parameters to ensure complete coverage and stereoscopic viewing. Overlap of approximately sixty percent between consecutive photos and sidelap of twenty to thirty percent between adjacent flight lines prevent gaps. Crab occurs when the aircraft is rotated relative to the flight line to compensate for wind, resulting in skewed images that must be corrected.

22. (B) Multi-Spectral Scanner
Multi-Spectral Scanner refers to an instrument that collects data across several wavelength bands simultaneously. In remote sensing, this technology allows for the identification of surface materials based on their unique spectral signatures. MSS sensors were famously used on early Landsat satellites to provide valuable information for geology, agriculture, and land use mapping on a global scale.

23. (D) The presence of highly fractured and cavernous limestone (karstic terrain).
Karstic terrain, characterized by highly fractured and cavernous limestone, is extremely unfavorable for reservoir construction. The presence of solution channels and underground caves allows water to leak easily from the basin, potentially leading to catastrophic water loss. Such permeable conditions compromise the primary function of a reservoir, which is to store water efficiently and safely behind a dam.

24. (A) P-2, Q-4, R-1, S-3
Scale is the ratio between distances on a photograph and the ground. Overlap ensures that consecutive photos include common areas for 3D viewing. A mosaic is a composite image formed by joining multiple individual photographs to cover a larger region. Tilt represents the angular deviation of the camera axis from the vertical, which introduces geometric distortions that must be corrected.

25. (C) Active sensors provide their own illumination source, while passive sensors detect external energy.
The fundamental distinction between active and passive remote sensing lies in the energy source. Active sensors, such as radar and lidar, transmit their own electromagnetic radiation toward the target and measure the reflected signal. Passive sensors, however, depend on external sources like the sun for reflected energy or the Earth itself for emitted thermal radiation to record surface data.

26. (A) The price of the camera lens
Interpretation of aerial photographs relies on visual characteristics like tone, color, texture, pattern, shape, and size to identify geological and man-made features. These elements provide clues about the nature of the terrain. The financial cost

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(C) The color of the safety vests worn by the workers.
(D) The brand of heavy machinery used.

273. The difference between `drift` and `crab` in aerial photography is:
(A) `Drift` is intentional, `crab` is accidental.
(B) `Drift` is a lateral shift of the whole aircraft from the flight line, while `crab` is a rotation of the aircraft to counteract wind, causing the photo to be skewed relative to the flight line.
(C) `Drift` is a rotation, and `crab` is a lateral shift.
(D) They are two names for the same phenomenon.

274. Which type of EMR has the longest wavelength and is used in active remote sensing systems like SAR?
(A) Microwave
(B) Near Infrared
(C) Thermal Infrared
(D) Visible light

275. Consider the following statements regarding fiducial marks:
(i) They are used to define the photograph's internal coordinate system.
(ii) They are used to locate the principal point.
(iii) They appear as small marks in the corners or on the sides of the photo.
Which of the above statement(s) is/are correct?
(A) (i) only
(B) (i) and (ii) only
(C) (ii) and (iii) only
(D) (i), (ii), and (iii)

276. For a gravity dam, what is the most important property of the foundation rock?
(A) Its high bearing strength to support the weight of the dam.
(B) Its color.
(C) Its high permeability to allow water to drain away.
(D) Its potential for containing valuable gems.

277. The interpretation of geomorphology from remote sensing imagery involves identifying:
(A) Individual mineral grains.
(B) Landforms such as river terraces, alluvial fans, and glacial moraines.
(C) The chemical composition of the atmosphere.
(D) The internal structure of the Earth.

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278. Which of the following is an example of an application of GIS?
(A) Identifying all areas that are within 1 km of a known fault and have a slope greater than 20 degrees.
(B) Calculating the load-bearing capacity of a steel beam.
(C) Writing a letter in a word processor.
(D) Editing a digital photograph to improve its color balance.

279. The purpose of having approximately 60% 'overlap' in aerial photography is to:
(A) Make the photographs more expensive.
(B) Ensure full stereoscopic coverage for 3D viewing.
(C) Allow the pilot to take a break between exposures.
(D) Reduce the amount of film used.

280. A TIRLS (Thermal Infra-Red Line-Scanner) measures:
(A) Reflected sunlight.
(B) Emitted thermal energy (heat) from the surface.
(C) Reflected microwave energy.
(D) The elevation of the ground surface.

281. The main reason geology is important in highway construction is to:
(A) Locate the most scenic routes, regardless of cost or stability.
(B) Assess the stability of slopes, the suitability of foundation materials, and the availability of construction aggregates.
(C) Determine the appropriate speed limit.
(D) Name the highways after famous geologists.

282. Which of the following is NOT a standard type of dam?
(A) Gravity Dam
(B) Inflatable Dam
(C) Arch Dam
(D) Dam and reservoir (as a combined concept)

(D) Embankment dam

264. What is the 'principal point' of an aerial photograph?
(A) The point on the ground directly below the camera.
(B) The point where the optical axis of the camera lens intersects the film plane, typically found by joining the fiducial marks.
(C) The highest point of elevation shown in the photograph.
(D) The point with the best image clarity.

265. Remote sensing is useful in the study of lithology because different rocks:
(A) Have different names.
(B) Have different spectral reflectance and emittance properties.
(C) Are always found in different geographic locations.
(D) Have different weights.

266. Discrete Image Processing" refers to the processing of an image that has been:
(A) Sampled into a grid of pixels and quantized into a set of gray levels or colors.
(B) Processed using analog optical methods.
(C) Hand-drawn by an artist.
(D) Kept secret from the public.

267. Which of the following is NOT an engineering property of a rock?
(A) Compressive strength
(B) Permeability
(C) Porosity
(D) Paleontological significance

268. Match List I with List II.
List I: (Term)
P. Faults and Joints
Q. Permeability
R. Compressive Strength
S. Slope Stability
List II: (Relevance to Engineering Geology)
1. Critical for highway cuts and open-pit mines.
2. A rock's ability to withstand crushing loads (important for foundations).
3. Planes of weakness in rock; potential pathways for water.
4. Governs seepage into tunnels and out of reservoirs.
Choose the correct answer from the options given below:
(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-4, R-2, S-1
(C) P-3, Q-2, R-4, S-1
(D) P-2, Q-4, R-1, S-3

269. The 'flight plan' for an aerial survey must specify:
(A) The names of all passengers on the aircraft.
(B) The flight lines, flying altitude, and camera settings to achieve the desired photo scale and coverage.
(C) The menu for the in-flight meal.
(D) The brand of the airplane.

270. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : Photogeology and remote sensing are particularly useful for studies in inaccessible regions.
Reason (R) : They provide a bird's-eye view of the terrain, allowing for the mapping of geology and landforms without the need for extensive and difficult ground access.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

271. In a GIS, the data that describes the characteristics of a geographic feature (e.g., the name of a river, the population of a city) is called:
(A) Vector data
(B) Raster data
(C) Attribute data
(D) Symbology

272. A key geological consideration in the construction of tunnels, highways, bridges, and canals is:
(A) The stability and properties of the ground on which or through which the structure is built.
(B) The astrological sign under which construction begins.

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292. The reflectance of clear, deep water is highest in which part of the visible spectrum?
(A) Red
(B) Blue
(C) Yellow
(D) Green

293. Consider the following geological issues for a major construction project:
(i) The presence of expansive soils (swelling clays).
(ii) The potential for seismic shaking (earthquakes).
(iii) The depth to a competent, load-bearing rock layer.
Which of the above statement(s) is/are correct regarding engineering considerations?
(A) (i) only
(B) (i) and (ii) only
(C) (ii) and (iii) only
(D) (i), (ii), and (iii)

294. Arrange the following steps for a geological investigation for a tunnel in a logical order:
1. Detailed site investigation with drilling and geophysical surveys along the final alignment.
2. Route selection based on detailed analysis.
3. Regional study using remote sensing and geological maps to identify possible corridors.
4. Preliminary field reconnaissance of potential routes.
Choose the correct answer from the options given below:
(A) 3, 4, 2, 1
(B) 1, 2, 3, 4
(C) 4, 3, 1, 2
(D) 3, 1, 2, 4

295. The primary difference between a continuous image processing system and a discrete image processing system is:
(A) Continuous processing is a theoretical concept using functions, while discrete processing is digital/computational.
(B) One is fast, the other is slow.
(C) Continuous is for color, discrete is for black and white.
(D) Continuous systems are older and obsolete.

296. A 'flight plan' is essential for aerial photography because it:
(A) Is required by international aviation law for all flights.
(B) Guarantees good weather for the survey.
(C) Ensures the area is covered systematically and efficiently to meet the project's goals for scale and overlap.
(D) Provides the pilot with a list of tourist attractions to see.

297. A key application of remote sensing in geomorphology is:
(A) The analysis of landforms and drainage patterns to infer geological processes and history.
(B) Determining the absolute age of a landform.
(C) Excavating landforms to see what is inside.
(D) Creating artistic paintings of landscapes.

298. What is the most significant disadvantage of a passive optical remote sensing system (like LISS or a camera) compared to an active microwave system (like SAR)?
(A) Passive systems have much lower resolution.
(B) Passive systems cannot see through clouds and cannot operate at night without a light source.
(C) Passive systems are much more expensive.
(D) Passive systems cannot detect color.

299. In the context of engineering geology, the term 'competent rock' refers to a rock that is:
(A) Able to pass an examination.
(B) Highly permeable and porous.
(C) Strong, stable, and able to support a load without failure or excessive deformation.
(D) Soft and easily excavated.

300. The term 'Vertical Exaggeration' in stereoscopy is a result of:
(A) The camera lens being of poor quality.
(B) The ratio of the photographic base to flying height being greater than the human eye base to viewing distance.
(C) The interpreter looking at the photos for too long.
(D) An intentional digital manipulation to make mountains look bigger.

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ANSWERS

1. (B) To record photographic images simultaneously in several different, narrow spectral bands.
Multi-spectral photography captures data in multiple narrow spectral bands simultaneously. This allows for detailed analysis of surface materials by exploiting their unique spectral signatures across the electromagnetic spectrum. It provides much more information than broad-band panchromatic imagery, facilitating precise differentiation between vegetation types, rock units, and soil moisture levels in complex geological and environmental studies.

2. (A) Vertical exaggeration is the perceived stretching of the vertical scale relative to the horizontal scale in a stereo model.
Vertical exaggeration occurs in stereoscopic viewing when the vertical scale appears larger than the horizontal scale. This phenomenon helps interpreters identify subtle relief features in terrain. Relief displacement is radial from the nadir, while tilt displacement occurs due to non-vertical camera orientation. Distortions are inherent in perspective projections and require specific photogrammetric corrections for accurate mapping.

3. (C) The lateral shift of the aircraft from the planned flight line, caused by wind.
Drift refers to the lateral displacement of an aircraft from its intended flight path due to the influence of crosswinds. If the pilot does not adjust the aircraft's heading, the resulting photographs will not follow the planned line, potentially creating gaps in coverage. This differs from crab, which is the aircraft's rotation to counteract such wind effects.

4. (D) Emitted thermal energy from the Earth's surface.
Thermal Infra-Red Line-Scanners detect energy emitted from the Earth's surface as heat rather than reflected solar radiation. This emitted energy is in the thermal infrared region of the electromagnetic spectrum. These sensors are essential for mapping temperature variations, identifying geothermal activity, monitoring forest fires, and conducting night-time imaging based on the thermal properties of different surface materials.

5. (A) Both A and R are true and R is the correct explanation of A.
Engineering a dam requires comprehensive geological study because the foundation must support immense weight and prevent water leakage. Rock types, structures like faults, and permeability directly determine the project's safety and effectiveness. A thorough investigation ensures that the underlying geology can handle the hydraulic pressure and structural loads, making the reason a direct explanation of the necessity.

6. (B) Spectral resolution
Spectral resolution refers to the ability of a sensor to define fine wavelength intervals. A higher spectral resolution means the sensor can distinguish between narrower bands of the electromagnetic spectrum. This capability is vital for identifying specific materials, such as different types of minerals or vegetation health, which exhibit distinct reflectance patterns in very specific wavelength ranges.

7. (D) A Side-Looking Airborne Radar (SLAR) system.
Active sensors provide their own source of electromagnetic radiation to illuminate the target. Side-Looking Airborne Radar systems emit microwave pulses and measure the energy reflected back to the sensor. This differentiates them from passive sensors, like cameras or scanners, which rely on external energy sources such as sunlight or thermal heat emitted naturally from the Earth's surface.

8. (B) (i) and (ii) only
Photo-geologic maps are created through the systematic interpretation of geological features directly from aerial images. They often provide superior detail regarding surficial deposits compared to traditional maps because they capture subtle topographic and tonal variations.

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However, they do not eliminate the need for ground-truthing, as field verification remains essential to confirm interpretations and collect samples during investigation.

9. (C) It causes the vertical scale to appear larger than the horizontal scale, accentuating relief.
In stereoscopic interpretation, vertical exaggeration is a perception where the vertical dimensions of the terrain appear stretched relative to the horizontal scale. This effect makes slopes seem steeper and heights appear greater than they are in reality. This exaggeration is beneficial for geologists as it highlights subtle topographic features that might otherwise be overlooked on standard flat images.

10. (A) P-3, Q-4, R-1, S-2
Different remote sensing instruments operate in specific regions of the electromagnetic spectrum. Linear Imaging Self-Scanning sensors typically use visible and near-infrared bands for land mapping. Thermal Infra-Red Line-Scanners detect emitted heat, while Synthetic Aperture Radar utilizes microwaves to penetrate clouds. Aerial film photography primarily records images in the visible spectrum using sunlight for illumination and detail.

11. (D) The variation in elevation of the ground surface.
Relief displacement is a geometric distortion in aerial photographs caused by the varying elevation of ground features. Points at higher elevations are displaced radially outward from the principal point compared to their true planimetric positions. This phenomenon is intrinsic to perspective projections and is the fundamental principle that enables stereoscopic viewing and the calculation of ground object heights.

12. (B) The rock's ability to resist forces that tend to crush it.
Compressive strength is an engineering property that quantifies the ability of a rock to withstand loads that tend to crush or reduce its size. It is a critical factor in civil engineering projects, especially for foundations of heavy structures like dams and bridges. This value helps engineers determine if the underlying rock can support the planned structural weight.

13. (C) The brand of the GPS unit used by the ground crew
Planning an aerial survey involves technical parameters like the required photo scale, the primary purpose of the imagery, and the optimal time or season to ensure clear ground visibility. While GPS units are necessary for navigation and georeferencing, the specific brand of the unit used by ground personnel is irrelevant to the fundamental flight and photographic parameters.

14. (A) 3, 2, 5, 4, 1
The remote sensing process begins with an energy source or illumination. This energy interacts with the atmosphere and the Earth's surface before being sensed by the sensor. The recorded data is then transmitted, received, and processed. Finally, the information undergoes data analysis and interpretation to extract meaningful geological or environmental insights for the end user or researcher.

15. (A) Healthy green vegetation
Healthy green vegetation exhibits very high reflectance in the near-infrared region due to the internal cellular structure of the leaves. While vegetation absorbs visible red light for photosynthesis, it strongly scatters near-infrared energy. This characteristic makes infrared imagery exceptionally useful for monitoring forest health, crop vigor, and distinguishing vegetated areas from soil, water, or man-made surfaces.

16. (B) Principal points
The principal point is the geometric center of an aerial photograph, determined by the intersection of lines connecting opposite marks on the image. These marks define the internal coordinate system of the photograph. Identifying this point is essential for photogrammetric tasks, including measuring relief displacement, calculating heights, and correcting geometric distortions for accurate map production and interpretation.

17. (D) A is false but R is true.
Passive remote sensing systems rely on naturally available energy, primarily solar radiation reflected from the Earth's surface. Consequently, sensors operating in the visible and near-infrared regions cannot function at night because there is no sunlight. While some passive sensors

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283. What is the fundamental requirement for stereoscopic (3D) viewing using aerial photographs?
(A) A single, high-resolution oblique photograph.
(B) A photograph taken at a very low altitude.
(C) Two overlapping photographs of the same area taken from different positions.
(D) A thermal infrared image.

284. 'Energy interaction with the Earth's surface' is a key remote sensing concept. When energy is absorbed by a surface, it is often:
(A) Perfectly reflected back to the sensor.
(B) Re-radiated at a longer wavelength (as heat).
(C) Destroyed and vanishes.
(D) Converted into microwaves.

285. In remote sensing, a 'whiskbroom' scanner (like MSS) and a 'pushbroom' scanner (like LISS) are two different methods for:
(A) Cleaning the sensor lens.
(B) Calculating the scale of the image.
(C) Transmitting data to the ground.
(D) Acquiring imagery line by line.

286. Which of the following geological conditions would be LEAST desirable for the foundation of a heavy structure like a gravity dam?
(A) Massive, unweathered granite.
(B) An uncompacted, water-saturated sand layer (prone to liquefaction).
(C) A thick sequence of well-consolidated sandstone.
(D) Hard, crystalline gneiss.

287. Which of the following is a primary application of photo geology in hydrogeology?
(A) Directly measuring the depth of the water table.
(B) Delineating fracture traces and permeable rock units that may control groundwater flow.
(C) Analyzing the chemical purity of groundwater.
(D) Installing water pumps by remote control.

288. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : Tilt in an aerial photograph causes a systematic displacement of image points.
Reason (R) : A tilted photograph results in a non-uniform scale across the image, which changes systematically with the direction and amount of tilt.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

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289. The difference between photogeology and remote sensing is that:
(A) Photogeology uses black and white photos, while remote sensing uses only color.
(B) Photogeology is done from the ground, while remote sensing is from space.
(C) There is no difference; the terms are perfectly interchangeable.
(D) Photogeology is a specific geologic application, while remote sensing is the broader science.

290. Match List I with List II.
List I: (Feature)
P. A single well location
Q. A river
R. A geological formation (map unit)
S. An elevation surface
List II: (Best GIS Representation)
1. Line
2. Point
3. Raster grid
4. Polygon
Choose the correct answer from the options given below:
(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-4, R-1, S-3
(D) P-4, Q-1, R-2, S-3

291. Lining of a tunnel" is done to:
(A) Make the tunnel look more attractive to tourists.
(B) Support the surrounding ground and control water inflow.
(C) Provide a place to hang advertisements.
(D) Increase the weight of the mountain above.

of the equipment, such as the price of a camera lens, does not provide any information for the analytical interpretation of images.

27. (D) Synthetic Aperture Radar
Synthetic Aperture Radar is a form of active microwave remote sensing. It uses the motion of the sensor platform to simulate a much larger antenna, which results in significantly higher spatial resolution than traditional radar systems. SAR is particularly valuable because it can operate during the day or night and can penetrate clouds, smoke, and light rain for continuous monitoring.

28. (A) Both A and R are true and R is the correct explanation of A.
Clear, deep water bodies appear dark in near-infrared imagery because water is an excellent absorber of radiation in this spectral region. Since very little NIR energy is reflected back to the sensor, the resulting signal is minimal. This strong absorption allows for the precise delineation of shorelines and water bodies, as they contrast sharply with highly reflective vegetation and soil.

29. (C) Support surrounding rock mass, prevent collapse, and control groundwater seepage.
Lining a tunnel is a critical engineering measure used to provide structural support to the surrounding rock mass. It prevents collapses in weak or highly jointed rock and helps control groundwater seepage into the tunnel. By creating a stable and dry interior environment, the lining ensures the safety and longevity of the infrastructure, serving much more than just aesthetic goals.

30. (D) A continuous image has values at every point in a plane, while a discrete image is a pixel grid.
A continuous image is a mathematical representation where brightness values exist at every possible point in a two-dimensional plane. In contrast, a discrete image is a digital representation where the scene is sampled into a grid of individual pixels. Each pixel has a specific numerical value representing intensity, allowing the image to be processed and manipulated using digital computers.

31. (A) The stability of slopes in cuts and fills, and the bearing capacity of the ground.
Engineering a highway involves assessing the stability of slopes in both cuts and fills to prevent landslides or erosion. Additionally, the bearing capacity of the underlying ground must be evaluated to ensure the roadbed can support the weight of traffic without excessive settlement. These geological factors are fundamental to the safety, maintenance, and durability of the transportation infrastructure.

32. (A) 2, 4, 3, 1
Electromagnetic radiation spans various wavelengths. Visible light occupies the shortest range among the given options, followed by the near-infrared region just beyond red light. Thermal infrared wavelengths, associated with heat, are longer than near-infrared. Microwaves possess the longest wavelengths in this group, often measured in centimeters or millimeters, and are used extensively in active radar remote sensing systems.

33. (B) Image Processing - GIS
Image processing and Geographic Information Systems are distinct but related fields. Image processing focuses on manipulating and enhancing digital images, such as those from satellites. GIS is a broader system for managing and analyzing spatial data across multiple thematic layers. While GIS often uses processed images, the two are not synonymous, making this pairing incorrect compared to the technical definitions.

34. (A) Map surface indicators like vegetation, moisture, and fractures to identify potential groundwater.
Remote sensing is used in hydrogeology to map surface features that indicate subsurface water. This includes identifying specific vegetation types that thrive near water, monitoring soil moisture levels, and mapping fracture zones or faults that may act as conduits for groundwater. While it cannot directly measure the water table depth from space, it identifies high-potential areas for drilling and detailed study.

35. (C) Principal point
The principal point is the precise geometric center of a vertical aerial photograph. It is the

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location where the optical axis of the camera lens intersects the film or detector plane. In perfectly vertical photography, this point coincides with the nadir. Locating the principal point is essential for photogrammetric measurements, as it serves as the origin for calculating relief displacement and scale.

36. (B) (i) and (ii) only
Geographic Information Systems organize data into thematic layers, allowing users to visualize complex relationships between different features. Spatial analysis, including overlay and proximity modeling, is a core function of GIS. While the system can handle both vector and raster data formats, the statement claiming it is limited only to vector data is incorrect, as raster grids are also fundamental to analysis.

37. (C) Its own weight and the shear strength of its foundation.
A gravity dam is a massive structure designed to resist the horizontal thrust of water primarily through its own weight. The downward force of the concrete or masonry creates friction and shear resistance at the foundation, preventing the dam from sliding or overturning. This design requires a strong, competent rock foundation capable of supporting the immense vertical load of the structure.

38. (B) Scale = Focal length / Flying height above ground
The scale of a vertical aerial photograph is determined by the ratio of the camera's focal length to the flying height of the aircraft above the ground. This relationship ensures that as the aircraft flies higher, the scale becomes smaller, covering more ground area. For accurate calculations, the flying height must be measured relative to the average terrain elevation rather than sea level.

39. (B) P-3, Q-4, R-1, S-2
Dams primarily require investigations into reservoir water-tightness. Tunnels are concerned with rock over-break and groundwater inflow during excavation. Highways focus on the stability of slopes in road cuts, while bridges depend on the geological nature of the rock at foundations and abutments. These specific geological concerns are critical for the design, safety, and economic success of each specific engineering project.

40. (A) Displacement of images caused by the camera lens not being perfectly vertical.
Tilt displacement is a geometric distortion that occurs when the camera's optical axis is not perfectly vertical at the moment of exposure. This results in a non-uniform scale across the photograph, as images are shifted from their true positions. This displacement radiates from the isocenter of the photo and must be corrected through photogrammetric techniques to create accurate geological and engineering maps.

41. (C) Linear Imaging Self-Scanning Sensor
Linear Imaging Self-Scanning Sensor is a type of pushbroom scanner used on various satellites, such as the Indian Remote Sensing series. It uses a linear array of detectors to capture a whole line of image data at once as the satellite moves forward. This technology provides high spatial and spectral resolution, making it suitable for detailed land use and geological mapping.

42. (A) Both A and R are true and R is the correct explanation of A.
Effective interpretation of aerial photographs requires prior knowledge of a region's geology, climate, and typical landforms. This background information allows the interpreter to distinguish between similar-looking features and correctly identify lithological units or structural trends. Without this context, interpretations can be ambiguous or incorrect, making geological expertise a vital component of the photogeologic process and ensuring map accuracy.

43. (D) Fossil content and age
Engineering geology focuses on physical properties that affect construction, such as compressive strength, shear strength, porosity, and permeability. These factors determine how rock will react under stress or fluid flow. While fossil content and the geological age of the rock are important for historical geology and stratigraphy, they are generally not considered primary engineering properties for civil engineering design.

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44. (B) It allows for the differentiation of surface materials based on their unique spectral signatures.
The primary benefit of multi-spectral photography is its ability to differentiate surface materials based on their unique spectral signatures. By capturing data in several narrow wavelength bands, including those outside the visible spectrum, interpreters can distinguish between various rock types, vegetation health, and soil conditions. This level of detail is impossible with panchromatic photography, which only records brightness in one band.

45. (C) The overlap between photos from two adjacent, parallel flight lines.
Sidelap is the overlap between photographs taken from adjacent, parallel flight lines in an aerial survey. It ensures that there are no gaps in coverage between the lines and provides a means to tie different strips of photographs together for mapping. Standard sidelap is typically around twenty to thirty percent, complementing the forward overlap used for stereoscopic viewing along flight lines.

46. (D) The ratio of the energy reflected from a material to the energy incident upon it.
Reflectance is a fundamental concept in remote sensing defined as the ratio of the energy reflected by a material to the total energy incident upon it. It is usually expressed as a percentage or a fraction between zero and one. Different materials exhibit characteristic reflectance values at different wavelengths, forming a spectral signature that allows for the identification of objects from imagery.

47. (A) Integrating and analyzing spatial data (e.g., geology, slopes, faults) for hazard zonation and site selection.
GIS is a powerful tool in engineering geology for integrating and analyzing various spatial datasets, such as lithology, fault locations, and slope steepness. By overlaying these layers, geologists can create hazard zonation maps and identify optimal sites for major infrastructure. This spatial analysis capability allows for informed decision-making regarding risk management and site suitability that traditional paper maps cannot easily provide.

48. (A) (i) and (ii) only
Geostationary satellites orbit at high altitudes to remain fixed over a single spot on Earth, while sun-synchronous satellites maintain a constant local solar time for consistent illumination. These orbits are essential for different remote sensing needs. However, the statement that platforms are limited to satellites is false, as sensors are frequently mounted on aircraft and drones for collecting spatial data.

49. (B) A region of folded sedimentary rocks with alternating resistant and non-resistant beds.
A trellis drainage pattern is highly characteristic of regions with folded sedimentary rocks. It forms where alternating layers of resistant and non-resistant rock are tilted or folded, creating parallel valleys and ridges. Tributary streams join main rivers at nearly right angles. This distinctive geometry is easily identified on aerial photographs and serves as a reliable indicator of underlying structural and lithological complexity.

50. (A) Mosaicking
Mosaicking is the process of assembling individual overlapping aerial photographs into a single, continuous image of a larger area. This technique allows for a regional view of the landscape that cannot be captured in a single frame. Mosaics can be controlled, using ground control points to correct for distortions, or uncontrolled, providing a quick but less geometrically accurate overview of the terrain.

51. (B) 1, 2, 4, 3
Remote sensing instruments are categorized by the wavelengths they detect. Radar systems operate in the microwave region, which has the longest wavelengths. Thermal scanners detect shorter thermal infrared energy. Near-infrared cameras capture even shorter wavelengths just beyond the visible spectrum. Multi-spectral scanners in the visible bands operate at the shortest wavelengths among these options, typically ranging from blue to red light.

52. (D) Longer microwave wavelengths are not significantly scattered by small particles or lack of sun.
Microwave radiation used in radar systems has much longer wavelengths than visible or infrared light. These longer waves are not significantly

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scattered by small atmospheric particles like water droplets in clouds or light rain. Additionally, because radar is an active system providing its own illumination, it can operate at night. This makes it a reliable tool for continuous Earth observation regardless of weather.

53. (C) Discrete image processing involves treating the image as a continuous function of brightness.
Discrete image processing involves treating an image as a matrix of numerical pixel values, which is the standard for digital computer systems. This contrasts with optical systems that might treat light as a continuous function. The other statements correctly describe image restoration for correcting distortions, enhancement for improving visual clarity, and classification for automatically categorizing pixels into different thematic or land cover groups.

54. (B) The bearing capacity and stability of the rock or soil at the locations of piers and abutments.
When investigating a site for a bridge, the primary geological focus is on the bearing capacity and stability of the material at the pier and abutment locations. The foundation must be able to support the concentrated structural loads and resist scour from the river. Understanding the rock or soil properties at these specific points is essential for ensuring safety and long-term structural integrity.

55. (B) P-3, Q-1, R-4, S-2
Pattern refers to the spatial arrangement of features, such as the grid-like joints in rock. Tone describes the relative brightness, like the contrast between wet and dry soil. Texture is the frequency of tonal change, distinguishing coarse conglomerate from smooth shale. Size allows for comparisons between large features like calderas and smaller ones like sinkholes, providing context for the geological scale.

56. (A) The redirection of EMR from its original path by particles and gas molecules.
Scattering is an atmospheric process where electromagnetic radiation is redirected from its original path by gas molecules and suspended particles. This diffusion is unpredictable and depends on the wavelength of the radiation and the size of the particles. It can reduce the clarity and contrast of remote sensing imagery, making it a critical factor to account for during data processing.

57. (C) Specify the flight lines, flying height, and photo positions to ensure systematic and complete coverage of the target area.
A flight plan in an aerial survey is a detailed blueprint that specifies the exact path of the aircraft, the flying height, and the positions for each exposure. Its primary goal is to ensure systematic and complete coverage of the target area with the required overlap and sidelap. This rigorous planning is necessary to produce high-quality imagery suitable for photogrammetric and geological interpretation.

58. (A) Both A and R are true and R is the correct explanation of A.
Rock types can be identified from remote sensing because each lithology has a unique mineralogical composition. These minerals interact with electromagnetic radiation in distinct ways, producing characteristic spectral signatures. By analyzing how much energy is reflected or emitted across different wavelengths, geologists can distinguish between various rock units, making remote sensing a powerful tool for mapping large areas efficiently and accurately.

59. (D) All structures are built on the Earth, making geology critical for design, safety, and longevity.
Geology is fundamental to civil engineering because every man-made structure is built upon or within the Earth. The physical and chemical properties of rocks and soils directly influence the design, safety, and durability of projects. Failure to account for geological factors like faults, groundwater, or unstable slopes can lead to structural failure, making geological knowledge essential for every stage of construction.

60. (B) The geological age of the rocks being photographed
The quality and appearance of an aerial photograph are influenced by environmental and technical factors such as the time of day, sun angle, seasonal vegetation, and atmospheric haze. However, the geological age of the rock itself does not directly affect the photograph. While the rock's physical characteristics might be visible, the millions of years since its formation have no technical impact.

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61. (D) (i), (ii) and (iii)
Different dam designs are suited to specific geological conditions. Arch dams require narrow valleys with strong rock abutments to transfer loads. Buttress dams use supports to distribute water pressure to the foundation. Embankment dams, constructed from earth or rock fill, are more flexible and can accommodate minor settlement in the foundation. All three statements accurately describe the fundamental structural principles of these types.

62. (D) The reflected solar radiation just beyond the visible red part of the spectrum.
Near-infrared imagery detects reflected solar radiation in the region of the electromagnetic spectrum immediately beyond the visible red light. It is particularly sensitive to the cellular structure of healthy vegetation, which reflects NIR energy strongly. This makes it an invaluable tool for environmental monitoring, as it can distinguish between different plant species and assess their health effectively through remote sensing data.

63. (A) The terrain is perfectly flat and the photograph is perfectly vertical.
The scale of an aerial photograph is only truly constant across the entire image if the terrain is perfectly flat and the camera's optical axis is perfectly vertical at the time of exposure. In reality, variations in ground elevation and unintentional tilting of the aircraft cause the scale to change across different parts of the photo, necessitating geometric corrections for accurate photogrammetric mapping.

64. (B) SAR creates a long antenna synthetically, allowing higher spatial resolution independent of range.
Synthetic Aperture Radar offers a major advantage over real aperture systems by synthetically creating a very long antenna through the sensor's forward motion. This technique allows for much higher spatial resolution in the along-track direction, which remains independent of the distance to the target. This makes SAR a powerful tool for high-resolution imaging from satellites, where large physical antennas are impractical.

65. (B) Linear or curvilinear features, offsets in topography, and changes in rock type, drainage, and vegetation patterns.
Geological structures like faults and folds are identified on remote sensing imagery through their surface expressions. Interpreters look for linear or curvilinear features, offsets in topographic ridges, and sudden changes in drainage patterns or vegetation. These visual clues reveal the underlying structural geometry. Unlike ground-based measurements, remote sensing provides a regional perspective that makes these large-scale features much easier to recognize.

66. (A) To overlay layers of data such as rainfall, geology, land use, and slope to model and identify areas of high groundwater potential.
In hydrogeological studies, GIS serves as an integration tool for multiple data layers. By combining information on rainfall, lithology, land use, and slope, researchers can create sophisticated models to identify areas with high groundwater potential. This spatial analysis allows for the efficient targeting of field investigations and drilling sites, saving time and resources compared to traditional manual mapping methods.

67. (A) 3, 4, 1, 2
A logical geological investigation for a dam begins with a regional study using maps and remote sensing to identify potential areas. This is followed by preliminary field reconnaissance to narrow down the choices. Once a site is selected, detailed drilling and geophysical surveys are conducted to provide specific data for the engineering team. Finally, the dam's design is completed based on investigation.

68. (D) Relief displacement
The apparent leaning or shift of a tall building's top away from the center of an aerial photograph is a classic example of relief displacement. This geometric distortion occurs because the camera captures a perspective view, and features with height are projected differently than their ground-level counterparts. This displacement is radial from the principal point and is used in photogrammetry for height calculation.

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86. (B) A granite intrusion
On aerial photographs, a massive granite intrusion typically appears as a large, uniform area with a relatively light tone. It often exhibits a dendritic drainage pattern, which develops on homogenous materials where streams branch out randomly. These visual characteristics, combined with a lack of clear bedding or folding, allow geologists to distinguish intrusive igneous bodies from layered sedimentary rocks or volcanic flows.

87. (D) Floating Dam
Common dam designs include gravity, arch, and buttress dams, each using different structural principles to resist water pressure. Embankment dams made of earth or rock fill are also standard. A floating dam" is not a recognized type of permanent large-scale engineering structure for water storage. Dams must be firmly anchored to a solid foundation to ensure stability against massive hydraulic forces.

88. (D) (i), (ii) and (iii)
Relief displacement is the radial shift of an object's image from the principal point due to its elevation. This displacement increases as the object moves further from the center of the photo. Crucially, it is this phenomenon that creates the difference in perspective between overlapping images, which is what enables human eyes or stereoscopes to perceive terrain in three dimensions during stereoscopic viewing.

89. (C) A pair of overlapping photographs (a stereo pair) and a device to measure parallax.
Measuring the height of objects from aerial photographs requires a pair of overlapping images, known as a stereo pair. By viewing these images together, an interpreter can measure the parallax, which is the apparent shift in an object's position relative to its surroundings between the two photos. This parallax value allows for the precise calculation of heights and the creation of topographic models.

90. (B) P-3, Q-2, R-4, S-1
Visible light is used for standard land cover mapping. Near-infrared is essential for assessing vegetation health. Thermal infrared detects heat, making it useful for monitoring fires and urban temperatures. Microwaves are valuable for estimating soil moisture and can penetrate clouds for all-weather imaging. Each region of the spectrum provides unique information that contributes to a comprehensive understanding of the Earth's surface features.

91. (D) It provides information beyond what the human eye can see, aiding in material differentiation.
The key advantage of multi-spectral photography is its ability to capture data beyond the visible range of the human eye. By recording specific bands like near-infrared or shortwave infrared, it can reveal differences in material composition, moisture content, and vegetation health. This enhanced spectral information is vital for accurate lithological mapping, environmental monitoring, and resource exploration in complex geological terrains.

92. (B) Increasing the permeability of the surrounding rock mass.
Tunnel lining is designed to provide structural support, prevent rock falls, and control the inflow of groundwater, ensuring a safe and stable environment. It also creates a smooth surface for better ventilation and traffic flow. Increasing the permeability of the surrounding rock mass would be counterproductive, as it would lead to more water seepage and potentially weaken the stability of the excavation.

93. (C) Shorter wavelengths like blue light.
Rayleigh scattering is an atmospheric phenomenon where radiation is scattered by particles much smaller than its wavelength. This process is highly dependent on wavelength, being inversely proportional to the fourth power. As a result, shorter wavelengths, such as blue light, are scattered much more intensely than longer red or infrared waves. This is the primary reason why the sky appears blue.

94. (D) The potential for ground shaking, liquefaction, and surface faulting.
In seismically active regions, engineering projects must account for ground shaking, which can cause structural collapse. Other major hazards include liquefaction, where saturated soil loses strength during shaking, and surface faulting, which can tear through foundations. These geological risks are the most significant considerations for the design and safety of critical

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shaped the landscape over time. This includes identifying glacial features, river terraces, and volcanic landforms. This regional perspective is essential for understanding landscape evolution and identifying areas prone to hazards like landslides.

78. (D) A geologic map prepared primarily through the interpretation of features on aerial photographs, often supplemented by field checks.
A photo-geologic map is a specialized map produced primarily through the systematic interpretation of geological features on aerial photographs. It captures details like lithological contacts, faults, and folds based on their visual expression. While it is a powerful tool for mapping large areas quickly, it is often supplemented by targeted field checks to ensure the accuracy and reliability of interpreted data.

79. (A) Permeability
Permeability is the engineering property that quantifies a rock's ability to allow fluids, such as water, to flow through its interconnected pore spaces or fractures. This is a critical factor in civil engineering for assessing seepage under dams, water inflow into tunnels, and groundwater movement. It is distinct from porosity, which only measures total volume of void space regardless of connectivity.

80. (B) Detecting thermal anomalies, such as forest fires, volcanic activity, or thermal pollution in water.
Thermal Infra-Red Line-Scanners are uniquely suited for detecting temperature anomalies on the Earth's surface. They are used to monitor active volcanic processes, locate the boundaries of forest fires, and identify thermal pollution in water bodies. Because they measure emitted heat rather than reflected sunlight, these sensors are also effective for night-time operations where temperature differences reveal features invisible to standard cameras.

81. (B) Minimizing water loss through seepage by avoiding highly permeable materials along the route.
For canal construction, minimizing water loss is a primary engineering goal. Geologists must identify and avoid highly permeable soil or rock along the route that could lead to excessive seepage. If permeable materials are unavoidable, the canal must be lined. Additionally, assessing the stability of slopes in canal cuttings is essential to prevent landslides that could block or damage the waterway.

82. (A) The misalignment of the photograph's edges with the flight line due to the aircraft's yaw.
Crab is a condition in aerial photography where the aircraft's longitudinal axis is not aligned with the intended flight line. This usually happens when the pilot must yaw the plane into the wind to maintain a straight path. As a result, the edges of the photographs are skewed relative to the flight line, complicating the creation of accurate mosaics and engineering maps.

83. (A) Both A and R are true and R is the correct explanation of A.
In an aerial photograph, the scale is determined by the ratio of the focal length to the flying height. If the terrain has relief, the flying height above mountain peaks is less than above valleys. Consequently, features at higher elevations are captured at a larger scale than those at lower elevations. This variation makes the scale non-uniform, necessitating photogrammetric geometric correction.

84. (D) Proximity analysis (Buffering)
Proximity analysis, often called buffering, is a GIS function used to identify areas within a specified distance of a geographic feature. In this case, creating a five-hundred-meter zone around a river helps identify areas at risk of flooding or those subject to specific environmental regulations. This spatial tool is fundamental for planning, environmental impact assessments, and hazard management across engineering projects.

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85. (C) Microwave Radar (SAR)
Microwave Radar, particularly Synthetic Aperture Radar, has the unique ability to see" through thick cloud cover, smoke, and haze. This is because microwave wavelengths are much longer than those of visible or infrared light and are not scattered by small atmospheric particles. This all-weather capability makes SAR indispensable for continuous monitoring of the Earth's surface during disaster response operations.

121. (D) Near Infrared (NIR)
Healthy green vegetation has a very distinct spectral signature with a sharp peak in reflectance in the near-infrared region. While plants reflect some green light, they reflect far more NIR energy due to the internal structure of their leaves. This dramatic increase in reflectance is the primary way remote sensing identifies and monitors vegetation health and land cover across space.

122. (A) 1, 3, 4, 2
Different engineering projects have varying sensitivities to geological permeability. A standard office building is generally the least sensitive, provided the foundation is stable. Highways are more sensitive due to the need for drainage to prevent roadbed saturation. Canals are highly sensitive as they must minimize seepage losses. Large dams and reservoirs are the most sensitive to underlying ground permeability issues.

123. (C) They represent known ground control points.
Fiducial marks are permanent reference marks built into the camera and projected onto the film during exposure. They define the internal coordinate system of the photograph and are used to locate the principal point. However, they do not represent ground control points. Ground control points are specific, surveyed locations on the Earth's surface used to georeference the photograph during mapping.

124. (A) Both A and R are true and R is the correct explanation of A.
Remote sensing is a highly cost-effective tool for the initial stages of mineral exploration. It allows geologists to quickly survey vast, often inaccessible regions to identify key geological features. These include structural trends like faults and alteration zones where specific mineral assemblages produce distinct spectral signatures. By narrowing down large areas, remote sensing saves significant time and money during exploration.

125. (B) The safety, stability, and economic viability of the project.
The primary goal of studying rock engineering properties is to ensure the safety, stability, and economic viability of civil engineering projects. By understanding parameters like compressive strength, shear resistance, and permeability, engineers can design foundations and tunnels that can withstand expected loads. This technical assessment is essential for preventing structural failures and optimizing construction costs for major infrastructure projects.

126. (B) The fundamental concepts and terminology of acquiring and using photographs taken from an aerial platform.
The study of aerial photography focuses on the technical principles and terminology involved in acquiring and using images taken from above. This includes understanding flight planning, camera systems, image scale, and the geometric distortions inherent in perspective views. It provides the foundation for more advanced fields like photogrammetry, equipping practitioners with knowledge to correctly interpret features from an aerial perspective.

127. (B) It scatters and absorbs the energy, modifying the signal that reaches the sensor.
As electromagnetic radiation travels from the sun to the Earth and then back to a sensor, it must pass through the atmosphere. Atmospheric gases and particles scatter and absorb this energy at various wavelengths. This process modifies the signal that eventually reaches the sensor, often reducing clarity. Understanding these atmospheric interactions is crucial for correcting remote sensing data for interpretation.

128. (C) The uniformity and bearing capacity of the foundation materials at each pier location.
Constructing a long bridge with multiple piers requires a thorough assessment of the geology at each specific support location. Engineers must ensure that the foundation material at every pier and abutment has sufficient and uniform bearing capacity to support the structural weight. Variations in rock or soil strength across the site can lead to differential settlement, which could cause structural failure.

129. (D) (i), (ii), and (iii)
Nuclear power plants require highest safety levels, making several geological conditions extremely hazardous. An active fault line poses a risk of direct displacement. Compressible clay can lead to unstable foundations and settlement. Cavernous limestone may cause sudden collapses

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infrastructure like dams, bridges, and power plants in high-risk areas.

95. (A) The vehicle or medium that carries the sensor, such as a satellite or an aircraft.
A sensor platform refers to the vehicle or structure that carries a remote sensing instrument. Common platforms include satellites, aircraft, helicopters, and unmanned aerial vehicles. The altitude and stability of the platform determine the sensor's field of view and the resolution of the data collected. Choosing the right platform is a critical part of mission planning to ensure resulting data meets technical requirements.

96. (B) Water with high sediment content generally has higher reflectance in the visible bands than clear water.
The reflectance of water is influenced by its physical contents. While clear water reflects very little energy and appears dark, water with high sediment or suspended solids reflects more light in the visible bands, appearing brighter. This characteristic allows remote sensing to be used for monitoring water quality, as variations in tone indicate changes in turbidity or sediment load in water bodies.

97. (B) Sidelap - Overlap between adjacent photos in the same flight line
Sidelap is the overlap between photographs from adjacent, parallel flight lines. It is not the overlap between consecutive photos in the same flight line; that is known as forward overlap or simply overlap. Accurate terminology is essential in aerial survey planning to ensure flight lines are correctly positioned to provide complete, gap-free coverage of the target area for geological mapping.

98. (A) Discrete image processing
Discrete image processing involves the manipulation of digital images using mathematical algorithms. In this system, an image is represented as a grid of pixels with specific numerical values. Transformation processes involve calculating new values for these pixels to enhance or restore data. This computational approach allows for precise and repeatable analysis that is the foundation of modern satellite imagery and digital photography.

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99. (A) Both A and R are true and R is the correct explanation of A.
GIS is an invaluable tool for selecting sites for major engineering projects because it can handle multiple layers of geographic information simultaneously. By integrating data on topography, geology, and environmental hazards, it allows engineers to perform complex spatial analysis to find the safest locations. This ability to synthesize diverse datasets into a single analytical framework makes the reason a correct explanation.

100. (D) A high degree of water-tightness in the basin, provided by impermeable rock and soil.
The most critical geological requirement for a reservoir is its ability to hold water without significant leakage. This requires the basin to be composed of impermeable rock and soil, such as clay or massive granite. High permeability or features like sinkholes and major faults would lead to excessive water loss, making the reservoir ineffective and potentially destabilizing the surrounding structures.

101. (C) 2, 3, 1, 4
To measure a feature's area on an aerial photograph, the first step is to delineate its boundary. Next, the area within that boundary on the photo itself must be calculated using a grid. Because the photo's scale is known, this value must then be adjusted by determining the average scale. Finally, the photo area is converted into true ground area using the scale factor.

102. (B) Faults often manifest as linear topographic features, offsets in rock layers, or alignments of vegetation and drainage.
Faults are identified on aerial photographs through their physical manifestation on the landscape. They often create linear topographic features, such as straight valleys, and cause visible offsets in rock layers. Additionally, faults can influence vegetation growth or drainage patterns, creating alignments recognized from a bird's-eye view. These indirect visual clues are the primary way structural features are mapped using remote sensing.

69. (C) Healthy vegetation shows low reflectance in the green and high reflectance in the near-infrared.
Reflectance characteristics vary significantly between materials. Healthy vegetation reflects weakly in the green and very strongly in the near-infrared, a feature used to monitor plant vigor. Water absorbs NIR energy strongly, appearing dark, rather than bright. Rock reflectance depends on mineralogy and grain size. Understanding these spectral signatures is fundamental to the accurate interpretation of remote sensing data for regional mapping.

70. (A) Both A and R are true and R is the correct explanation of A.
Tunneling through sequences of hard and soft rock is challenging because these materials respond differently to excavation and structural loads. Hard rocks may concentrate stress, while soft rocks can deform or squeeze, leading to uneven pressure on the tunnel lining. This differential behavior can compromise structural integrity, making specialized engineering and geological assessment essential for the safety of the project.

71. (D) Refraction within the sensor's lens
Remote sensing involves energy interacting with the Earth's surface through reflection, absorption, and transmission. These processes determine the signal recorded by the sensor. While refraction occurs when light passes through the sensor's lens, this is an internal mechanical process of the instrument itself and is not considered part of the energy's interaction with the Earth's surface or atmosphere during data acquisition.

72. (A) Pre-existing information about the geology, climate, and vegetation of the study area.
Background knowledge in photogeology refers to the pre-existing geological, climatic, and environmental information an interpreter has about a study area. This context is crucial because visual patterns on a photograph can represent different geological features depending on the regional setting. Expertise in local geology helps resolve ambiguities and ensures that interpretations are accurate and consistent with known ground-based survey conditions.

73. (B) P-4, Q-1, R-2, S-3
Vector data represents features as discrete points, lines, or polygons. Raster data consists of a grid of pixels, each containing a value. Attribute data provides non-spatial information, such as the name or age of a feature. Overlay analysis is the core GIS process of superimposing different data layers to analyze spatial relationships and derive new information for various engineering projects.

74. (A) Tilt
Tilt is a geometric distortion in an aerial photograph caused by the camera's optical axis being inclined from the vertical at the moment of exposure. This results in the ground appearing tilted in the image and creates a non-uniform scale. Unlike relief displacement, which is caused by terrain height, tilt is a result of aircraft orientation and requires photogrammetric correction.

75. (A) (ii) only
Passive remote sensing systems can detect energy in the thermal infrared region, which is emitted as heat, allowing for night-time imaging of features like volcanoes or forest fires. Active systems, however, are not constrained by sunlight because they provide their own illumination. Radar is an active system, not passive, as it transmits microwave pulses and measures the recorded return signal.

76. (B) It determines the sun angle (for shadows) and the state of vegetation cover, which can either reveal or obscure ground features.
The timing of an aerial survey is critical because it controls the sun's angle and the state of vegetation. Low sun angles create shadows that highlight subtle topography, while seasons with minimal leaf cover allow for a clearer view of the underlying geology. Choosing the right time ensures that necessary features are visible and not obscured by environmental factors during analysis.

77. (C) Mapping landforms and analyzing drainage patterns to understand landscape evolution.
Remote sensing is used in geomorphology to identify and map various landforms and drainage patterns. By analyzing these surface features, geologists can reconstruct the processes that have

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112. (B) The perception of slopes and heights as being steeper and greater than they actually are.
Vertical exaggeration in stereoscopic viewing creates a perception where the vertical scale is larger than the horizontal scale. This causes slopes to appear steeper and topographic features to look much more dramatic than in reality. While this makes the model less planimetrically accurate, it is a valuable tool for geologists, as it helps identify subtle landforms and structural trends.

113. (D) Chromatic aberration
Relief displacement, tilt displacement, and vertical exaggeration are fundamental geometric principles that describe how images are projected and perceived in aerial photography. These factors are critical for photogrammetry and mapping. Chromatic aberration, however, is an optical defect of a lens where different colors are focused at different points. It is not a fundamental geometric principle governing the spatial projection.

114. (B) Ensure there are no gaps in coverage and to allow for stereoscopic (3D) viewing.
Forward overlap is a critical requirement in aerial photography, typically set at sixty percent between consecutive images. Its primary purpose is to ensure complete coverage of the terrain without gaps and to enable stereoscopic viewing. By capturing the same area from two slightly different positions, the overlap allows the interpreter to see the landscape in three dimensions, enhancing geological analysis.

115. (B) Identifying the precise in-situ stress conditions of deep bedrock.
Photo geology is highly effective for mapping regional structures, identifying surface landforms, and classifying broad lithological units. However, it cannot identify precise, in-situ stress conditions of deep bedrock. Measuring these stresses requires direct physical testing, such as borehole measurements or laboratory analysis of rock samples. Remote sensing is limited to observing surface expressions and cannot provide data on deep mechanics.

116. (B) Pushbroom scanner
A Linear Imaging Self-Scanning camera is a classic example of a pushbroom scanner. Unlike whiskbroom scanners that use a rotating mirror to scan point by point, a pushbroom scanner uses a linear array of detectors. This array captures an entire line of image data simultaneously as the satellite moves forward along its path. This design is reliable and provides high image quality.

117. (B) (i) and (ii) only
GIS is a sophisticated analytical tool used for modeling complex scenarios, such as potential flooding areas of a reservoir or the susceptibility of a landscape to landslides. By integrating and analyzing various data layers like geology, slope, and rainfall, GIS provides critical insights for engineering and hazard management. The claim that it has no analytical capabilities is technically false.

118. (C) Sound, unweathered, high-strength rock like granite or gneiss.
A concrete gravity dam exerts immense pressure on its foundation and must resist the force of stored water through its own weight. Therefore, it requires a foundation of sound, unweathered, and high-strength rock like granite or gneiss. Such rock provides necessary bearing capacity and shear resistance. Loose soil or cavernous limestone would be unable to support the structural load safely.

119. (A) SAR achieves higher azimuth resolution by synthesizing a larger antenna aperture.
The key technical difference between Synthetic Aperture Radar and Side-Looking Airborne Radar is how they achieve spatial resolution. SLAR uses a real, physical antenna, which limits its resolution based on the antenna's size. SAR, however, uses the motion of the platform to synthetically create a larger antenna aperture. This allows for significantly higher resolution that is independent of range distance.

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120. (P) P-1, Q-3, R-2, S-4
Relief displacement is caused by variations in terrain elevation. Tilt displacement results from the camera axis being non-vertical. Scale variation across a photograph is a combination of both terrain relief and the effects of camera tilt. Crab is a specific condition where the aircraft yawed relative to the flight line, causing the photos to be skewed during an aerial survey.

103. (A) It relies on detecting solar energy reflected from the Earth's surface.
Passive remote sensing systems are characterized by their reliance on naturally available energy sources. Most passive sensors detect solar radiation reflected from the Earth's surface during the day. Because they do not emit their own energy, they are constrained by lighting conditions and are generally unable to see" through thick clouds, distinguishing them from active sensors like radar systems.

104. (D) (i), (ii) and (iii)
Porosity and permeability are distinct but related properties. Porosity measures the total void space, while permeability measures how easily fluids flow through those spaces. A rock can have high porosity but low permeability if the pores are not interconnected, such as in certain volcanic rocks. All three statements correctly describe these fundamental properties, which are essential for assessing groundwater flow.

105. (A) The bearing capacity and potential for settlement of the underlying foundation material.
When a highway is constructed on a fill embankment, the primary geological concern is the bearing capacity of the original ground. If the foundation consists of compressible materials like soft clay, the weight of the fill can cause significant settlement over time. This can lead to pavement cracking and structural damage, making a thorough assessment of the underlying material's strength essential.

106. (A) P-2, Q-1, R-4, S-3
Bridge pier foundations are primarily concerned with the bearing capacity of the ground. Highway cuttings must be evaluated for slope stability to prevent landslides. Flooding by a dam requires assessment of reservoir tightness to ensure water storage. The lining of a water canal is essential for managing permeability and preventing seepage losses. These geological factors are critical for structural safety.

107. (B) The required scale, which in turn determines flying height and camera choice.
The intended purpose of an aerial photography mission is a fundamental controlling factor. It dictates the required image scale, which in turn determines the flying height of the aircraft and the choice of camera lens. By defining the mission's goal, planners can ensure that resulting photographs provide necessary information for the specific project requirements, ranging from urban planning to geology.

108. (A) The attribute table
The attribute table is the component of a GIS that stores non-spatial information associated with geographic features. While the spatial data defines where a feature is, the attribute table describes what it is, such as a river's name or a road's surface type. This link between spatial and descriptive data allows for complex queries and analysis, making GIS powerful.

109. (A) A computer-based system that treats an image as a grid of pixels (a matrix of numbers) and manipulates these numbers.
A discrete image processing system is a computer-based framework that treats a digital image as a finite grid of pixels. Each pixel is assigned a numerical value representing its color or intensity. By manipulating these numbers through mathematical algorithms, the system can enhance or classify the image. This digital approach is the standard for modern remote sensing and mapping tasks.

110. (A) Both A and R are true and R is the correct explanation of A.
Microwave remote sensing is highly valuable for studying water because the dielectric constant of water is much higher than that of dry soil. This significant difference causes a strong radar backscatter response, making the sensor sensitive to variations in soil moisture and surface water. This physical relationship allows radar to effectively map hydrological features and assess ground moisture conditions.

111. (D) Relief displacement
The apparent leaning of a utility pole in an aerial photograph, where the top is shifted further from the center than its base, is a result of relief displacement. This geometric distortion occurs because photographs are perspective projections. Features with height are shifted radially outward from the principal point based on elevation. This phenomenon is used in photogrammetry to determine true heights.

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or groundwater issues. All three conditions must be avoided or rigorously mitigated to ensure the structural integrity of the nuclear facility.

130. (C) Creates a continuous picture of a large area that is too big to be covered by a single photograph.
A mosaic is an assembly of overlapping aerial photographs that provides a continuous view of a large geographic area. Its primary advantage is that it allows researchers to see regional patterns and features that are too extensive to be captured in a single photograph. Mosaics provide a comprehensive, large-scale visual overview of the landscape for regional geological and environmental studies.

131. (A) A theoretical concept where an image is treated as a continuous function, often processed using optical methods.
A continuous image processing system is a conceptual or optical framework where an image is treated as a continuous two-dimensional mathematical function rather than a set of discrete points. This approach often involves optical methods using lenses and filters to manipulate light directly. It represents the theoretical counterpart to digital discrete systems, which treat images as grids of pixels.

132. (B) The Earth's surface features and the processes that create and change them.
Geomorphology is the scientific study of the Earth's surface features and the processes, such as erosion and tectonics, that create and modify them. In remote sensing, geomorphology involves identifying landforms like mountains and river systems from imagery. This analysis helps geologists understand Earth's history, predict changes, and identify potential geomorphic hazards like landslides or coastal erosion.

133. (B) P-2, Q-1, R-4, S-3
SAR stands for Synthetic Aperture Radar, an active microwave system. MSS is the Multi-Spectral Scanner, used for capturing data in several bands simultaneously. TIRLS refers to the Thermal Infra-Red Line-Scanner, which detects emitted heat. LISS is the Linear Imaging Self-Scanning Sensor, a type of pushbroom scanner. Each acronym represents a distinct technology providing specific types of information about the surface.

134. (B) A major fault zone with crushed rock and potential for groundwater flow.
A major fault zone is a primary concern for tunnel alignment because it typically consists of crushed, weak rock that can easily collapse during excavation. Additionally, faults often act as conduits for groundwater, which can lead to sudden and dangerous inflows. Navigating such structural defects requires extensive engineering support, making them far more hazardous than stable sedimentary formations for tunnels.

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135. (B) Late fall or early spring, when leaf cover is minimal, exposing the ground surface and rock outcrops.
For geological mapping in forested regions, the most effective time for an aerial survey is during late fall or early spring. During these periods, the lack of leaf cover on trees exposes the ground surface and rock outcrops that would otherwise be hidden. This allows for a clearer view of lithological contacts and structural features, improving interpretation of imagery.

136. (B) To identify surface indicators of groundwater, such as fracture traces, vegetation anomalies, and drainage patterns.
In hydrogeology, photo geology is most effectively used to identify surface indicators that suggest the presence of groundwater. Interpreters look for fracture traces in the bedrock, which act as underground conduits, as well as vegetation anomalies or specific drainage patterns. While it cannot directly see the water table, it provides a regional overview that guides geologists to promising locations.

137. (C) A distance on the photograph and the corresponding distance on the ground.
The scale of an aerial photograph is a fundamental ratio that expresses the relationship between a distance measured on the photo and the actual corresponding distance on the ground. It is typically represented as a representative fraction, such as 1:20,000. Understanding the scale is essential for making accurate measurements of features and for creating regional maps from remote sensing data.

187. (B) It can directly measure the age of rock formations in millions of years.
Remote sensing is a powerful tool for monitoring land use, mapping environmental hazards, and identifying groundwater zones. However, it cannot directly measure the absolute age of rock formations. Determining a rock's age in millions of years requires laboratory analysis of isotopes from physical samples collected in the field. Remote sensing provides information about physical properties but does not provide temporal dating data.

188. (D) (i), (ii), and (iii)
Planning an aerial photography flight is a complex process that requires several key parameters. The required scale of the photos determines the flying altitude. The geographical extent of the target area must be defined to plan flight lines. Additionally, the time and season must be chosen to ensure optimal ground visibility. All three statements are correct, as they represent the fundamental factors considered.

189. (C) Thermal Infrared
Energy emitted as heat from the Earth's surface falls within the thermal infrared region of the electromagnetic spectrum. Sensors operating in this range detect the radiant temperature of features, allowing for mapping of volcanic activity and forest fires. Unlike visible or near-infrared sensors that measure reflected sunlight, thermal sensors provide a unique view of the landscape and can operate effectively during both day and night.

190. (C) To identify and mitigate geological hazards, ensuring the project's safety, stability, and long-term performance.
The primary goal of incorporating geological considerations into major engineering projects is to identify and mitigate potential hazards. By understanding rock and soil properties and groundwater conditions, engineers can design structures that are safe, stable, and durable. This proactive approach prevents structural failure, reduces accident risk, and ensures long-term performance of infrastructure, making geological knowledge an essential component of engineering design.

191. (B) The point on the ground directly beneath the camera lens at the moment of exposure.
The nadir is the point on the Earth's surface directly beneath the camera lens at the moment an aerial photograph is taken. In a perfectly vertical photograph, the nadir coincides with the principal point of the image. The nadir is a critical reference point in photogrammetry, as it serves as the origin for relief displacement, which radiates outward from this point during mapping.

192. (A) Passive remote sensing
Passive remote sensing systems are those that detect naturally available energy. This most commonly includes solar radiation reflected from the Earth's surface during the day, as well as thermal energy naturally emitted by the Earth as heat. These sensors do not provide their own source of illumination, which distinguishes them from active systems like radar. Passive sensors are the most common type used.

193. (D) A photograph shows a perspective view with geometric distortions, whereas a map is an orthographic projection with a uniform scale.
While an aerial photograph and a map may appear similar, they have fundamental geometric differences. A photograph is a perspective projection where scale varies due to terrain relief, and features are displaced from their true locations. A map, however, is an orthographic projection where every point is viewed from directly above, resulting in a uniform scale. Converting a photograph into a map is the goal.

194. (A) A collection of geographic data of the same type or theme, such as a layer for roads, a layer for rivers, and a layer for elevation.
In a Geographic Information System, a layer is a fundamental way of organizing spatial data based on a common theme or feature type. For example, one layer might contain roads, while another shows elevation. By stacking these layers, users can visualize complex spatial relationships and perform analyses across different datasets. This layered structure allows GIS to effectively manage and interpret vast amounts.

195. (A) Both A and R are true and R is the correct explanation of A.
Healthy green vegetation exhibits high reflectance in the near-infrared region, which makes it

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scene. This design has largely been replaced by pushbroom scanners in newer systems.

147. (A) Flight Plan - Specifies the required image scale and coverage.
A flight plan is the essential blueprint for an aerial survey, specifying the required image scale, flight lines, and the extent of coverage needed. This planning ensures that the photography is systematic and fits project goals. The other terms were incorrectly defined: overlap refers to consecutive photos in a single line, sidelap to adjacent lines, and crab to the aircraft's yaw.

148. (A) Different rock types often have different spectral reflectance characteristics and weathering patterns.
Identifying different rock types from remote sensing is possible because each rock unit often possesses distinct physical and chemical characteristics. These variations result in unique spectral reflectance signatures across different wavelengths. Furthermore, different rocks weather into characteristic landforms. By analyzing these visual and spectral clues, geologists can distinguish between various rock units from a regional perspective, making mapping far more efficient.

149. (D) Radiometric resolution
Radiometric resolution refers to a sensor's ability to distinguish small differences in the intensity of electromagnetic radiation it receives. It is often measured in bits; for example, an 8-bit sensor can distinguish 256 levels of brightness. Higher radiometric resolution means the sensor can capture more subtle variations in the scene, which is critical for identifying materials with very similar reflectance.

150. (B) P-3, Q-1, R-4, S-2
A gravity dam relies on its massive structure's weight for stability. An arch dam uses a horizontal arching action to transfer the water load to side abutments. A buttress dam is supported by a series of structural buttresses. An embankment dam, made of earth or rock fill, depends on the shear strength and weight of its materials for resisting water pressure.

151. (A) To assess soil and rock permeability to prevent seepage losses, and to evaluate slope stability for cuttings.
Geological investigation for canals focuses on preventing water loss and ensuring structural stability. Geologists evaluate the permeability of rock and soil along the route to identify areas where seepage could occur, necessitating lining. Additionally, the stability of slopes in canal cuttings must be assessed to prevent landslides. These factors are essential for the efficient transport of water across distances.

152. (D) LISS (Linear Imaging Self-Scanning Sensor)
Active sensors like SAR, SLAR, and Lidar provide their own source of illumination, such as microwave or laser pulses, and measure the reflected signal. This allows them to function regardless of sunlight. A LISS camera, however, is a passive sensor that relies on solar radiation reflected from the Earth's surface. It cannot generate its own energy, meaning it acquires data only during daylight.

153. (A) Both A and R are true and R is the correct explanation of A.
Stereoscopic viewing is a vital technique in photogeology that uses overlapping pairs of aerial photographs to create a three-dimensional model of the terrain. This 3D perspective allows the interpreter to see vertical relief, making it easier to identify landforms and delineate geological structures. By providing a realistic view of the ground, stereoscopy significantly enhances the accuracy of regional geological interpretation.

154. (B) Infrared
Infrared radiation occupies the portion of the electromagnetic spectrum with wavelengths longer than visible red light but shorter than microwaves. It is divided into sub-regions, including near-infrared, useful for vegetation studies, and thermal infrared, used to detect emitted heat from the Earth's surface. This range provides critical information for remote sensing that is beyond the capability of standard optical cameras.

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be a fault or a cultural boundary. By understanding regional geological context, the interpreter can narrow down possibilities and provide a more accurate identification. This contextual expertise is what distinguishes professional geological interpretation from simple visual observation.

172. (C) The brand of GPS receiver in the pilot's personal phone.
A flight plan is a technical document outlining scale, flight lines, altitude, and coverage needed for an aerial survey. These parameters are determined by the project's scientific and engineering requirements. While navigation equipment like GPS is used, the personal devices of the crew have no bearing on the fundamental planning of the mission. Technical specifications of the camera and aircraft are the only influencing factors.

173. (B) The bearing capacity of the foundation material under the abutments and piers.
The most important geological factor for bridge construction is the bearing capacity of the material at foundation points. Bridge piers concentrate massive structural loads onto small areas of ground. If the rock or soil at these locations is weak, the bridge could settle unevenly or collapse. Geologists must ensure foundation material can support these loads and resist environmental forces like river scour for stability.

174. (D) (i), (ii), and (iii)
Remote sensing utilizes various imaging sensors to collect data about the Earth's surface. Linear Imaging Self-Scanning sensors use pushbroom technology for detailed mapping. Synthetic Aperture Radar is an active microwave system for all-weather imaging. Multi-Spectral Scanners capture data in multiple wavelength bands using mechanical scanning. All three are essential tools providing unique information, functioning as imaging sensors by recording the spatial distribution of energy.

175. (A) Tilt displacement
Tilt displacement is a geometric distortion that occurs in an aerial photograph when the camera's optical axis is not perfectly vertical. This displacement shifts the positions of objects on the image, causing a non-uniform scale and distorting the shapes of features. It radiates from the isocenter. Correcting for tilt is a fundamental task in photogrammetry to ensure resulting maps are planimetrically accurate for engineering and surveying.

176. (B) Overlaying a map of active faults with a map of proposed infrastructure to identify high-risk zones.
A classic application of GIS in engineering geology is performing an overlay analysis between different thematic layers. By combining a map of known active faults with a map of proposed infrastructure, engineers can identify high-risk zones where construction should be avoided or where special designs are required. This spatial capability allows for integration of diverse datasets to support risk assessment and site selection efficiently.

177. (A) They create long shadows that enhance the subtle expression of topography and linear features.
In photogeology, taking aerial photographs when the sun is low in the sky can be highly advantageous. The resulting long shadows accentuate subtle topographic relief, making features like low ridges and linear fault traces much more visible than they would be under direct overhead light. This enhanced micro-relief provides critical clues for the interpreter to identify underlying geological structures and landforms during mapping.

178. (B) 2, 1, 4, 3
Creating a photo-geologic map starts with acquiring overlapping aerial photographs to ensure complete coverage and stereoscopic capability. Next, geologists delineate features like lithological contacts and structural trends directly on the photos. This interpreted linework is then transferred to a planimetrically accurate basemap. Finally, field checks are performed to verify interpretations on the ground and collect samples, ensuring final map accuracy and reliability.

179. (A) To support the rock mass and prevent collapse into the tunnel opening.
The primary structural role of tunnel lining is to provide support to the surrounding rock or soil mass. By resisting pressures from the ground

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and map the regional geometry of features like faults, folds, and joints. Remote sensing provides a unique vantage point that reveals large-scale structural patterns and lineaments. This mapping is essential for understanding tectonic history and for identifying structural weaknesses that may affect engineering project stability.

164. (A) To identify sources of aggregate for construction and to assess the stability of slopes in cuts and the foundation for fills and bridges.
Geological investigation for highways is multifaceted. It involves identifying suitable sources of rock for construction aggregate. More critically, geologists assess the stability of slopes in road cuts to prevent landslides and evaluate foundation conditions for bridges and heavy embankments. These technical assessments ensure the highway is built on stable ground and can withstand environmental stressors, which is vital.

165. (B) P-2, Q-3, R-4, S-1
Data capture involves digitizing physical maps into digital format. Spatial analysis is the core function of performing operations like overlays between thematic layers. Data management involves organizing and storing information in structured databases for easy access. Data display is the final step of creating visual products, such as maps showing specific hazard zones, to communicate findings and support decision-making.

166. (B) Geostationary satellite
A geostationary satellite orbits at an altitude of approximately thirty-six thousand kilometers directly over the equator. At this height, the satellite's orbital period matches the Earth's rotation, making it appear fixed over a specific geographical location. This orbit is ideal for communications and weather satellites, as it allows for continuous monitoring of the same area. Other satellites maintain different orbital paths.

167. (A) It contains significant geometric distortions and scale variations, making it unsuitable for accurate measurements.
An uncontrolled mosaic is created by simply joining individual aerial photographs without correcting for geometric distortions or scale variations. While it provides a quick overview of a large area, it is not planimetrically accurate. Because of relief displacement and tilt, features may not align perfectly at the joins. This makes it unsuitable for precise measurements or for accurate geological and engineering mapping.

168. (B) Creates a picture-like representation of the scene being observed.
An imaging sensor is an instrument that detects electromagnetic radiation and records its spatial distribution to create a picture-like representation of the scene. Unlike non-imaging sensors that provide a single numerical value, imaging sensors like cameras and scanners provide detailed spatial information. This allows for the identification of features based on shape and size, which is fundamental for interpreting imagery.

169. (A) Both A and R are true and R is the correct explanation of A.
The selection of a dam site is primarily a geological decision because the safety of the structure depends on the underlying materials. Weak rock can lead to settlement and structural failure, while permeable formations can cause catastrophic leakage from the reservoir. A thorough geological investigation identifies these potential hazards, ensuring the reason correctly explains why geological considerations are paramount for dam projects.

170. (D) Sonic waves
Remote sensing is based on the detection of electromagnetic radiation, which includes visible light, microwaves, infrared, and ultraviolet waves. These forms of energy travel at the speed of light and can pass through a vacuum. Sonic waves, however, are mechanical vibrations that require a physical medium to travel. While used in underwater sonar, they are not a form of electromagnetic radiation used in standard remote sensing.

171. (A) Similar features on a photo can have different geological explanations depending on the regional context.
Background knowledge is essential in photogeology because many geological features can have similar visual appearances on a photograph. For example, a linear feature might

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155. (C) A controlled mosaic, where photos are corrected for distortions and fitted to ground control points.
For a mosaic of aerial photographs to be used for precise geographic measurements, it must be a controlled mosaic. This involves using ground control points to correct for the geometric distortions and scale variations inherent in individual photographs. The images are adjusted and fitted together to form a planimetrically accurate representation of the area, making it a reliable tool for engineering.

156. (C) Overlay Analysis
Overlay analysis is a fundamental GIS operation where different thematic layers are superimposed to identify spatial relationships. In this case, combining a geological map with a topographic map reveals areas that share specific characteristics. This analysis is essential for identifying potential hazards, such as locations prone to landslides, and for supporting complex decision-making processes in engineering and environmental management.

157. (A) Microwave imagery primarily measures surface roughness and dielectric properties, while thermal infrared measures surface temperature.
Microwave and thermal infrared imagery provide very different types of information. Microwave imagery, typically from radar, is sensitive to surface roughness and dielectric properties, useful for studying soil moisture. Thermal infrared, however, measures energy emitted as heat, providing a map of surface temperatures. Both are essential for a comprehensive remote sensing analysis, but they operate on different physical principles and wavelengths.

158. (D) (i), (ii), and (iii)
Tunneling is a complex engineering task that faces several major geological challenges. Swelling clays can exert enormous pressure on linings when wet. High in-situ stresses in deep rock can lead to rockbursts or squeezing ground. Encountering a water-bearing fault can cause dangerous flooding and instability. All three conditions represent significant risks that must be carefully evaluated and mitigated during construction.

159. (A) The difference in parallax between the top and bottom of an object on a stereo pair.
The height of objects on aerial photographs is most commonly measured using the principle of parallax. This involves viewing a stereoscopic pair of overlapping images and measuring the difference in the apparent position of the object's top and bottom. This parallax difference, combined with flight data and photo centers, allows photogrammetrists to calculate true height with high precision for engineering tasks.

160. (B) The pre-determined flight lines and required overlap/sidelap percentages.
A successful aerial photography mission relies on a precise flight plan that details the flight lines and required overlap and sidelap percentages. These parameters ensure the entire area is covered systematically and that there is sufficient common imagery for stereoscopic viewing and mapping. Proper planning is essential for producing high-quality data that meets geometric and analytical requirements of the survey.

161. (D) Near-infrared and beyond
Water absorbs electromagnetic radiation effectively, especially at longer wavelengths. While it reflects some light in blue and green bands, its reflectance drops significantly in the red band and becomes almost zero in the near-infrared and beyond. Because of this high absorption, water bodies appear very dark in NIR imagery. This characteristic makes infrared data extremely useful for identifying and mapping shorelines.

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162. (A) A dense, crystalline, unweathered granite.
Crystalline igneous rocks like granite generally possess the highest compressive strength because of their interlocking mineral structure and high density. In contrast, sedimentary rocks like poorly cemented sandstone are much weaker because they have less internal cohesion. Weathering also significantly reduces strength. For heavy foundations, unweathered granite is often the ideal choice because of its ability to support massive crushing loads.

163. (B) Map the location, extent, and geometry of features like faults, folds, and joints.
The primary objective of using photogeology and remote sensing for structural studies is to identify

above and around the excavation, the lining prevents collapses and ensures the tunnel's long-term stability. While it also helps control groundwater and provides a smooth surface, its fundamental engineering purpose is to maintain the integrity of the opening.

180. (A) It ensures that images of any given location are always acquired at approximately the same local solar time, providing consistent illumination conditions.
A sun-synchronous orbit is highly beneficial for Earth observation because it ensures that a satellite passes over any given location at approximately the same local solar time. This consistency provides uniform illumination and shadow conditions between acquisition dates, making it easier to detect changes on the Earth's surface. This orbit is a standard choice for environmental mapping satellites that require repeatable imagery.

181. (A) P-3, Q-1, R-2, S-4
Geographic Information Systems are primarily used for spatial data analysis and integration. Synthetic Aperture Radar is a technology for active microwave imaging. Photogrammetry is the science of making measurements from photographs, such as calculating heights and distances. Thermal Infra-Red Line-Scanners are instruments designed for detection of emitted thermal energy. Together, these terms represent the core technologies used in modern mapping.

182. (D) Airborne Lidar (Light Detection and Ranging) or SAR
Mapping topographic features beneath a dense forest canopy is challenging for optical sensors because vegetation obscures the ground. Airborne Lidar and Synthetic Aperture Radar are much more effective in these environments. Lidar uses laser pulses that can penetrate foliage to reach the surface, while SAR uses microwaves less affected by vegetation. Both technologies create high-resolution digital elevation models of the ground.

183. (A) Both A and R are true and R is the correct explanation of A.
Karstic limestone is a difficult foundation for dams because it is characterized by solution features like underground caverns. These interconnected channels create high permeability, which can lead to rapid and catastrophic water loss from the reservoir. Furthermore, the presence of voids can compromise dam stability. A thorough geological assessment of such terrain is essential, as the reason correctly explains this major hazard.

184. (B) The frequency of tonal change and arrangement of individual features too small to be discerned individually, creating a characteristic appearance (e.g., smooth, coarse, mottled).
In photo interpretation, texture refers to the visual appearance created by the frequency of tonal change and the arrangement of small features. Features that are too small to be seen individually, like rocks in a conglomerate, combine to create a characteristic texture that may be smooth or mottled. This element helps interpreters distinguish between different land covers and rock types effectively.

185. (A) Basics cover the fundamentals, while `Continuous` refers to optical processing and `Discrete` refers to digital processing of images as pixels.
Image processing can be divided into three main areas. Basic concepts cover fundamental principles of how images are captured and manipulated. Continuous image processing refers to theoretical or optical methods where images are treated as continuous functions. Discrete image processing is the digital approach used by computers, where images are sampled into grids of pixels. Understanding these is essential for remote sensing.

186. (A) To ensure the stability of cuts and fills and provide a solid foundation for bridges and roadbeds.
Knowledge of rock engineering properties is vital for highway construction to ensure project safety and longevity. Geologists must evaluate the strength of rock and soil to design stable cuts through hills and solid foundations for bridges. Without this information, roads would be prone to landslides and settlement. By providing a stable foundation, these assessments prevent structural damage and reduce maintenance costs.

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issues. Identifying such permeable conditions is a critical part of investigation.

204. (C) Vertical photographs and oblique photographs.
Basic studies in aerial photography cover fundamental differences between various types of images, most notably vertical and oblique photographs. Vertical photographs are taken with the camera pointed straight down and are used for mapping and photogrammetry. Oblique photographs are taken at an angle, providing a natural perspective useful for visual reconnaissance but more difficult for precise measurement and geometric coordinate calculation.

205. (C) Penetrate clouds, haze, and light rain, and to operate day or night.
The primary advantage of microwave imagery, such as radar, is its all-weather and day-night capability. Microwave radiation has much longer wavelengths than visible light, allowing it to pass through thick clouds, smoke, and light rain without significant scattering. Furthermore, because radar is an active system providing its own illumination, it can acquire clear images in darkness. This makes it a reliable tool.

206. (B) Integrating various spatial datasets (geology, slope, land use, rainfall) to delineate groundwater potential zones.
GIS is a powerful tool in hydrogeological studies for integrating diverse spatial datasets. By overlaying layers of information—such as lithology, faults, slope steepness, and rainfall—researchers can identify and delineate groundwater potential zones. This spatial analysis allows geologists to visualize how these different factors interact to influence groundwater movement, providing a more comprehensive and efficient way to target field investigations.

207. (A) The phenomenon where the vertical scale of the stereo model appears stretched relative to the horizontal scale.
Vertical exaggeration is a perception in stereoscopic viewing where the vertical scale appears larger than the horizontal scale. This effect makes terrain look more dramatic, with steeper slopes than in reality. For geologists, this exaggeration is significant because it highlights subtle topographic features like fault scarps and minor landforms that might be difficult to see on a flat image during interpretation.

208. (A) Both A and R are true and R is the correct explanation of A.
The choice of season for an aerial survey is a critical factor in photogeology. Conducting photography during periods of minimal vegetation cover ensures that underlying geology is visible and not obscured by leaves. Additionally, choosing a time with an optimal sun angle can create shadows that highlight micro-relief and structural trends. This strategic timing maximizes useful information captured in photographs.

209. (A) Different minerals have characteristic absorption and reflection features at different wavelengths, which can be used to identify them.
The reflectance of minerals is a key concept in remote sensing because each mineral has a unique chemical composition and crystalline structure. These properties cause minerals to reflect and absorb electromagnetic radiation at specific wavelengths, creating a characteristic spectral signature. By analyzing these signatures in multi-spectral imagery, geologists can identify different mineral types and map the mineralogical composition of large geographic areas.

210. (B) The rock type, its structural condition (faults, joints), groundwater conditions, and in-situ stresses.
Tunneling is a high-risk engineering project where geological conditions are the primary concern. Designers must account for the rock type, structural integrity—including the presence of faults and joints—and local groundwater conditions. Additionally, high in-situ stresses in the rock can cause dangerous instability during excavation. Understanding these complex factors is essential for designing safe support systems and appropriate construction methods.

211. (C) The aircraft, satellite, or other vehicle on which the sensor is mounted.
In remote sensing, a sensor platform is the vehicle or structure that carries the instrument used to collect data. Common platforms range from drones and aircraft to balloons and orbiting satellites. The choice of platform determines the sensor's altitude, stability, and path, which in turn

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appear bright on NIR imagery. This phenomenon is caused by the internal cellular structure of healthy leaves, which scatters NIR radiation rather than absorbing it. This characteristic spectral response is a reliable indicator of plant vigor and is used extensively in remote sensing to monitor crop health and vegetation.

196. (A) Landforms and the processes that shape the Earth's surface.
The study of geomorphology using remote sensing focuses on identifying and analyzing landforms and the processes that shape the Earth's surface. By observing features like river channels and glacial valleys from above, geologists can reconstruct landscape history and predict future changes. This regional analysis is essential for identifying geomorphic hazards like landslides, providing critical information for land use planning and environmental management.

197. (A) The presence of strong, impermeable rock at the foundation and abutments.
Selecting a dam site requires a foundation and abutments composed of strong, impermeable rock. The rock must be able to support the weight of the structure and resist the thrust of stored water. Furthermore, low permeability is essential to prevent excessive seepage from the reservoir. Features like massive granite are ideal, while fractured rock types must be avoided to ensure dam project safety.

198. (A) Relief displacement is caused by terrain elevation, while tilt displacement is caused by the camera's orientation.
Relief displacement and tilt displacement are two distinct geometric distortions in aerial photography. Relief displacement is caused by variations in elevation and radiates from the nadir. Tilt displacement, however, is a result of the camera's optical axis being non-vertical and radiates from the isocenter. Both distortions must be corrected through photogrammetric processes to create accurate maps, but they result from different physical causes.

199. (D) Synthetic Aperture Radar
Synthetic Aperture Radar is an advanced form of active microwave remote sensing. By using the motion of the platform to simulate a much larger antenna, SAR achieves significantly higher spatial resolution than traditional real-aperture radar systems. This technology is particularly valuable because it provides all-weather, day-and-night imaging capability and can penetrate clouds and smoke, making it indispensable for regional topographic mapping.

200. (D) (i), (ii), and (iii)
Tunnel lining serves several critical purposes in engineering. It provides structural support to the surrounding rock mass, preventing collapses in weak or fractured ground. Additionally, it helps to seal the tunnel and control groundwater inflow, ensuring a dry interior. The smooth surface of the lining also improves the aerodynamic profile for ventilation and enhances safety. All three statements correctly describe these essential functions.

201. (A) P-3, Q-1, R-2, S-4
Drift refers to the lateral shift of an aircraft from its intended flight line due to crosswinds. Crab is the rotation of the aircraft to counteract these winds, which can cause photographs to be skewed. Overlap is the common area between consecutive images in a single line, necessary for 3D viewing. Sidelap is the overlap between adjacent, parallel flight lines, ensuring full coverage without gaps.

202. (A) The signal recorded by the sensor is a product of these complex interactions, and understanding them is key to interpretation.
The concept of energy interaction with the Earth's surface and atmosphere is fundamental to remote sensing because the signal recorded by a sensor is the result of these complex processes. Energy is scattered or absorbed by the atmosphere and reflected or transmitted by ground features. Understanding how different materials interact with radiation at various wavelengths is essential for correctly interpreting imagery and data.

203. (D) An underlying geology of highly permeable sandstone or cavernous limestone.
A reservoir's primary function is to store water efficiently, which requires an impermeable basin. Underlying geology composed of highly permeable sandstone or cavernous limestone is extremely unfavorable because it allows water to leak easily. This excessive seepage can lead to significant water loss, making the project ineffective and potentially causing stability

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138. (A) Both A and R are true and R is the correct explanation of A.
In a GIS, the vector data model is ideally suited for representing discrete geographic features like roads, rivers, and boundaries. This is because the model uses points for locations, lines for linear features, and polygons for areas, which directly mirror the geometry of these real-world objects. This accurate representation allows for precise mapping and complex spatial analysis of infrastructure.

139. (C) Focal length
Interpretation of aerial photographs relies on visual characteristics such as shape, size, tone, texture, pattern, and association of features. These elements provide clues necessary to identify objects and geological formations. While focal length is a technical parameter used to calculate scale and geometry, it is not an element of interpretation" used by the analyst to identify features during analysis.

140. (A) Bright in a panchromatic image.
Reflectance is the amount of incident energy reflected by a surface. In a panchromatic (black and white) image, materials with high reflectance in the visible spectrum—such as dry sand, snow, or concrete—will reflect a large amount of light and appear as bright white or light gray tones. Conversely, materials with low reflectance, like clear water, appear as darker shades.

141. (A) Assess the rock's strength, stability, and behavior during excavation to ensure safety and design support systems.
Studying rock engineering properties before tunneling is essential to evaluate how the ground will behave during excavation. Engineers need data on rock strength and structural defects to design safe support systems and to determine effective excavation methods. This assessment minimizes the risk of collapses and ensures project completion safely and efficiently, focusing on structural integrity and protection for workers.

142. (A) 2, 4, 1, 3
The history of remote sensing began with aerial photography for military use during World War I. This was followed by the development of airborne radar systems during World War II. A major milestone occurred in 1972 with the launch of the first Landsat satellite, providing global multi-spectral data. Recently, high-resolution commercial satellite imagery from platforms like IKONOS has transformed the field.

143. (D) (i), (ii), and (iii)
Tilt displacement and relief displacement are two distinct geometric phenomena in aerial photography. Tilt displacement radiates from the isocenter, while relief displacement radiates from the nadir. In a perfectly vertical photograph, the principal point, nadir, and isocenter all coincide. All three statements accurately describe fundamental geometric relationships used in photogrammetry to understand and correct distortions for accurate geological mapping.

144. (A) Any shift in the position of an image on a photograph that alters the perspective characteristics.
Distortion in an aerial photograph refers to any shift in an image's position that alters its perspective characteristics compared to a true map. These shifts are caused by various factors, including terrain elevation, the camera's orientation, and optical effects within the lens. Understanding and correcting these distortions is essential for photogrammetric measurement and for producing accurate orthophotos and maps from imagery.

145. (A) The spatial analysis of geographic data for planning and decision-making.
The primary application of a Geographic Information System is the spatial analysis of geographic data to support informed planning and decision-making. By integrating various layers of information—such as topography and land use—GIS allows users to visualize complex relationships. This capability is invaluable in fields like urban planning and engineering geology, where understanding spatial context is critical for project success.

146. (B) Uses a rotating mirror to scan the scene line by line, perpendicular to the direction of flight.
A whiskbroom scanner, also known as an across-track scanner, uses a rotating mirror to collect data. The mirror scans the terrain point by point in a series of lines perpendicular to the sensor's direction of flight. This mechanical scanning action sweeps the sensor's field of view across the

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influences the scale, resolution, and coverage of the resulting data. Selecting the platform is a vital part of planning.

212. (B) Multi-spectral photography captures data in specific, often narrow, wavelength bands, including those outside the visible spectrum (like NIR).
Multi-spectral photography is distinguished from standard color photography by its ability to capture data in multiple, specifically defined wavelength bands. While standard color photos record broad bands of blue, green, and red light, multi-spectral systems can capture narrow intervals and include regions outside the visible spectrum, such as near-infrared. This additional information allows for more detailed analysis of surface materials.

213. (D) (i), (ii), and (iii)
Geographic Information Systems are versatile tools used across many geological and engineering applications. They can analyze the spatial relationships between earthquakes and faults, plan efficient highway routes by considering multiple factors, and create landslide hazard maps by integrating data on slope, geology, and rainfall. All three statements are correct, as they highlight the core ability of GIS to synthesize diverse datasets.

214. (A) Allows for the calculation of the height of objects from photographs.
Relief displacement is a geometric distortion where the image of an object is shifted radially from the center based on its height. While this is a distortion, it is also useful in photogrammetry. By measuring the magnitude of this displacement on a single photo or stereo pairs, specialists can calculate true heights of ground features and topographic elevations for detailed map creation.

215. (C) A radar system (like SAR) is an active sensor because it provides its own illumination.
The fundamental difference between active and passive sensors lies in the source of the energy they detect. Active sensors, like radar, provide their own source of illumination by transmitting pulses of radiation and measuring the reflected signal. This allows them to operate in the dark. Passive sensors, such as cameras, depend on naturally available energy like reflected sunlight, making them dependent on environmental conditions.

216. (A) The aircraft's flying height above the ground and the camera's focal length.
The scale of an aerial photograph is primarily determined by two technical factors: the flying height of the aircraft above the ground and the focal length of the camera lens. This relationship is expressed as a ratio where scale equals focal length divided by flying height. By adjusting these parameters, survey planners can achieve the desired level of detail and ground coverage for mapping.

217. (B) Identifying surface features that are indirect indicators of groundwater presence.
Remote sensing is most effective in hydrogeology for identifying surface expressions that provide clues about subsurface water. Geologists use imagery to map fracture traces and specific drainage patterns that indicate high groundwater potential. While it cannot directly sample water quality from space, it provides a regional overview that is essential for guiding more detailed and expensive ground-based investigations and site drilling.

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218. (B) Control how the ground will behave when a load is placed upon it or a tunnel is excavated through it.
Engineering geology focuses on the physical properties of rocks because these characteristics determine how ground will behave when subjected to structural loads. Properties like compressive strength and permeability are critical for designing foundations and for ensuring the stability of tunnels and road cuts. Understanding these factors allows engineers to predict potential failures and design appropriate support systems for the structural safety.

219. (D) A squeezing ground" consisting of wet, sheared shale under high pressure.
Tunnel lining must be most substantial when tunneling through squeezing ground," which often consists of weak, wet rock like sheared shale under high pressure. In these conditions, the ground can deform plastically and exert massive pressure on the opening. A thick, reinforced lining is essential to resist these forces and

example, as it transmits microwave pulses and records the reflected signal. This differs from passive sensors like the human eye or thermal scanners, which rely on naturally available energy—either reflected sunlight or emitted heat—to detect ground information.

238. (B) Ensure there are no gaps in coverage between adjacent flight lines and to tie the lines together.
Sidelap is the overlap between photographs from adjacent, parallel flight lines in an aerial survey. Its primary purpose is to ensure no gaps in imagery between lines and to provide a mechanism to tie strips of photos together for consistent mapping. Combined with forward overlap, sidelap ensures the entire project area is captured systematically, which is essential for accurate mosaics.

239. (D) All structures are founded on the earth, and the properties of the earth materials dictate the design and safety of the structure.
The importance of geology in civil engineering is fundamental because all structures are built on the Earth. Physical properties of rock and soil determine how they will respond to structural loads. Failure to account for geological factors can lead to structural collapse or settlement. Therefore, geological investigation is a critical requirement for ensuring safety, stability, and performance of all civil projects.

240. (B) P-2, Q-1, R-4, S-3
Geomorphology is the study of the Earth's landforms and the processes that create them. Lithology focuses on the physical characteristics and types of rocks. Hydrogeology is the branch of geology concerned with the movement of groundwater. Structural geology deals with the arrangement and deformation of rock units, such as folds and faults. Together, these fields provide a comprehensive understanding of surface.

241. (A) Both A and R are true and R is the correct explanation of A.
Remote sensing is an invaluable tool for monitoring natural hazards because it provides rapid coverage of large areas. Satellite imagery can quickly map the extent of flooding, the boundaries of wildfires, and volcanic impact, providing critical information for emergency response. This ability to monitor dangerous regions safely and efficiently makes remote sensing a vital component of modern disaster management and regional planning.

242. (B) Raster data
In a Geographic Information System, raster data consists of a grid of cells where each cell contains a specific numerical value. This format is ideal for representing continuous surfaces that change across space, such as elevation, rainfall totals, or surface temperature. Each pixel represents a specific area on the ground, and its value provides the recorded information for that particular location.

243. (A) Relief displacement
The apparent leaning of a utility pole in an aerial photograph, where the top is displaced further from the center than its base, is a classic example of relief displacement. This distortion occurs because photographs are perspective projections, causing features with height to be shifted radially outward. The magnitude of displacement depends on object height and distance from the center, enabling height calculations.

244. (D) The permeability of the soil and rock along the route, which affects water loss.
The most important geological consideration for canal construction is the permeability of the rock and soil along the planned route. Canals are designed to transport water, and excessive seepage through permeable ground can lead to significant water loss and destabilize canal banks. Geologists must identify these high-permeability zones early so that engineers can design appropriate lining and water drainage systems.

245. (D) (i), (ii), and (iii)
Remote sensing utilizes a variety of sensors with unique capabilities. A LISS camera is a passive instrument that records reflected sunlight. A SAR system is an active microwave sensor that provides its own illumination. Thermal scanners detect emitted heat, particularly useful for identifying temperature anomalies at night. All three statements are correct, as they accurately describe fundamental operating principles used in mapping.

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overlap and sidelap to ensure complete coverage. Additionally, the time of day is crucial for achieving best sun angle and visibility. All three factors are essential for mission success.

229. (C) The general physical characteristics of a rock or rock unit.
Lithology refers to the general physical characteristics of a rock or rock unit, including its mineral composition, color, grain size, and texture. In photogeology, lithology is inferred from how different rocks weather, their tonal expression on photographs, and the landforms they create. Understanding these physical traits allows geologists to map different rock formations across large areas using remote sensing imagery.

230. (A) It accentuates subtle topographic features like low-angle dips of strata, making them easier to see.
Vertical exaggeration is a perception in stereoscopic viewing that makes the vertical dimensions of terrain appear larger than they are in reality. This phenomenon is advantageous for geological interpretation because it highlights subtle topographic relief. Small changes in elevation and minor fault scarps become much more apparent. This enhanced perspective allows geologists to identify and map structural features difficult to see on flat images.

231. (A) A mosaic is an assembly of photos, while a photo-geologic map is an interpretation of geology drawn from the photos.
A mosaic and a photo-geologic map serve different purposes. A mosaic is simply a collection of overlapping aerial photographs assembled to provide a continuous visual overview of a large geographic area. A photo-geologic map, however, is a scientific product representing a geologist's interpretation of lithology and structure. While the mosaic provides visual data, the map adds meaning through feature identification.

232. (D) A narrow canyon with strong rock in the abutments (sides).
An arch dam is a specialized structure most suitable for narrow canyons with strong, competent rock abutments. The design uses a horizontal arching action to transfer the massive thrust of the stored water to the sides of the valley. This requires the rock to be very stable and strong. Arch dams can be thinner than gravity dams, making them economical.

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233. (C) Near-infrared
Healthy green vegetation has a unique spectral signature with a sharp increase in reflectance in the near-infrared region, just beyond the visible spectrum. While plants reflect some green light, they reflect a much larger portion of NIR radiation due to the internal cellular structure of the leaves. This reflectance peak is the most reliable way remote sensing identifies and monitors vegetation health.

234. (A) Vector (lines)
In a Geographic Information System, a river network is best represented using a vector data format, specifically lines. This model accurately captures the linear and branching nature of rivers and their connectivity. Unlike raster grids, vector lines can store precise coordinate information for the path of the river and can be linked to attribute data like flow rates and names.

235. (A) 3, 4, 2, 1
Electromagnetic radiation covers a wide range of wavelengths. Among the options provided, visible light has the shortest wavelengths, ranging from about four hundred to seven hundred nanometers. Near-infrared radiation follows with slightly longer wavelengths. Thermal infrared energy has even longer wavelengths. Microwaves possess the longest wavelengths in this group. This progression is a fundamental concept in remote sensing spectral studies.

236. (D) The length of time an unsupported excavation in the rock will remain stable before it starts to collapse.
Stand-up time is a critical engineering parameter in tunnel design that refers to how long an unsupported excavation in rock will remain stable before a collapse begins. This time depends on the rock's strength and structural defects. It is a vital factor for safety, as it determines how quickly support systems like lining must be installed after excavation is performed.

237. (D) A Synthetic Aperture Radar (SAR) system.
An active sensor is one that provides its own source of energy to illuminate the target. A Synthetic Aperture Radar system is a prime

often serve as conduits for water movement. Additionally, identifying moisture-sensitive vegetation or specific drainage patterns provides clues about groundwater potential. This regional analysis guides geologists toward investigation locations.

288. (A) Both A and R are true and R is the correct explanation of A.
Tilt displacement is a geometric distortion that occurs when the camera's optical axis is not perfectly vertical during an aerial survey. This tilt results in a non-uniform scale because parts of the ground are closer to the camera than others. Features are shifted from their true planimetric positions, with displacement radiating from the isocenter. Correcting for tilt is a fundamental task.

289. (D) Photogeology is a specific geologic application, while remote sensing is the broader science.
Remote sensing is the broad scientific field used to collect information about Earth's surface from a distance using a wide range of the electromagnetic spectrum. Photogeology is a specific and focused application of these technologies to geology. It involves interpretation of aerial photographs and satellite imagery to map lithology and landforms. Photogeology is the specialized analytical discipline applying this spatial data.

290. (A) P-2, Q-1, R-4, S-3
In a Geographic Information System, different real-world features are best represented by specific data models. A single location, like a well, is represented as a point. Linear features such as rivers are modeled as lines. Areas with defined boundaries, like geological formations, are polygons. Continuous surfaces, such as elevation, are best modeled using a raster grid where each cell contains values.

291. (B) Support the surrounding ground and control water inflow.
Lining a tunnel is a critical engineering measure with two primary functions. First, it provides structural support to the surrounding ground, resisting pressure from rock and soil to prevent collapses and falls. Second, the lining acts as a seal to control inflow of groundwater, keeping the tunnel interior dry. By ensuring structural stability and water-tightness, lining is essential for long-term safety.

292. (B) Blue
Clear, deep water exhibits its highest reflectance in the blue portion of the visible spectrum. As wavelengths increase through green and red bands, water becomes increasingly absorptive, reflecting very little energy. This is why clear water appears blue to the eye and on standard color photographs. In the near-infrared region, absorption is even stronger, causing water bodies to appear very dark.

293. (D) (i), (ii), and (iii)
Major construction projects require a thorough evaluation of several key geological and engineering factors. Expansive soils can cause foundation failure. Seismic hazards like ground shaking must be accounted for in structural design, especially in high-risk regions. Additionally, determining the depth to a competent, load-bearing rock layer is essential for designing stable foundations. All three statements are correct, representing fundamental challenges.

294. (A) 3, 4, 2, 1
A logical geological investigation for a tunnel starts with a regional study using remote sensing and geological maps to identify potential corridors. This is followed by preliminary reconnaissance to narrow down choices. Once a promising alignment is identified, a detailed site investigation is conducted, involving drilling and geophysical surveys to provide data on rock strength. Finally, the tunnel design is completed.

295. (A) Continuous processing is a theoretical concept using functions, while discrete processing is digital/computational.
The primary difference between continuous and discrete image processing systems lies in how they represent and manipulate visual information. A continuous system is a theoretical or optical concept that treats an image as a continuous mathematical function. In contrast, a discrete image processing system is a digital framework where an image is sampled into a finite grid of pixels with specific numerical values.

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246. (A) Reference marks on an aerial photograph, used to define the internal geometry of the photo.
Fiducial marks are permanent reference points built into the camera and projected onto the corners or sides of an aerial photograph during exposure. They are used to define the internal coordinate system of the image and to locate the principal point. These marks are essential for photogrammetry, as they provide fixed references needed to measure distances and calculate photo scale accurately.

247. (A) Identify and map the surface expression of features like faults and folds over large areas.
The primary goal of using photogeology and remote sensing for structural studies is to identify and map the surface expression of features like faults and folds over large geographic areas. Imagery provides a regional perspective that reveals lineaments and structural trends. This mapping is essential for understanding tectonic history and for identifying structural weaknesses that may impact engineering projects or resource location.

248. (D) Varies depending on the elevation of the ground, being larger for higher ground.
The scale of an aerial photograph is determined by the ratio of focal length to flying height. In mountainous terrain, elevation varies across the scene. Therefore, the distance between the aircraft and the ground is less over mountain peaks than over valleys. As a result, scale is not uniform across the image; it is larger for features at higher elevations, requiring correction.

249. (A) Price/Cost
Interpreters use several primary visual elements to identify objects and geological features on aerial photographs, including texture, pattern, tone, shape, and size. These clues provide essential information about the nature of terrain. The financial cost of acquiring photographs, while a practical consideration, is not an element used in the analytical process of interpretation. It provides no information about physical or geological characteristics.

250. (A) The properties of the rock and soil to be excavated, groundwater conditions, and potential for instability.
The geological investigation for a tunnel is primarily concerned with the physical properties of materials to be excavated. Geologists must evaluate the strength of rock and soil, identify structural defects like faults, and assess groundwater conditions. These factors determine the risk of collapses and water inflow, which are critical for the safety of workers and the design of tunnel support systems.

251. (A) Mapping surface temperature variations, useful for detecting forest fires or geothermal activity.
A Thermal Infra-Red Line-Scanner is an instrument specifically designed to measure variations in surface temperature. Its primary application is mapping thermal anomalies, such as active volcanic processes, forest fire boundaries, and geothermal heat sources. Because it detects emitted thermal energy rather than reflected sunlight, it is also highly effective for night-time imaging. This provides critical information for disaster monitoring and environmental study.

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252. (B) Detect naturally available energy (like reflected sunlight or emitted heat).
Passive sensors are remote sensing instruments that detect naturally available energy. This includes solar radiation reflected from the Earth's surface during the day and thermal energy naturally emitted by the Earth as heat. These sensors do not provide their own source of illumination, which distinguishes them from active sensors like radar. Passive sensors are the most common type used in observation.

253. (D) To understand how a rock will behave under the stress of a foundation or in the wall of a tunnel.
Civil engineers are concerned with the engineering properties of rocks because these materials serve as foundations or hosts for structural projects. Properties like compressive strength and permeability determine how the ground will react under the heavy loads of a bridge or dam. Understanding these factors allows engineers to design safe and stable structures that can withstand expected stresses and environmental conditions.

maintain stability. In contrast, massive granite is self-supporting and requires less lining.

220. (P) P-4, Q-1, R-3, S-2
A standard photographic camera uses a lens to focus reflected light onto film or a detector. SLAR is an active microwave sensor that transmits its own pulses. LISS is a passive scanner that uses a pushbroom mechanism to record data in several bands. TIRLS is a passive sensor specifically designed to detect heat emitted from the Earth's surface for thermal mapping.

221. (B) The political affiliation of the pilot influences the photo's scale.
The quality and appearance of an aerial photograph are influenced by environmental and technical factors. Sun angle can enhance terrain detail, vegetation can hide ground features, and atmospheric haze can reduce contrast. However, the political background of the pilot has no technical impact on the photo's scale or geometric properties. These are determined solely by camera parameters, altitude, and technical mission requirements.

222. (D) A dam and reservoir.
Reservoir tightness is the most critical geological consideration for the construction of a dam and reservoir. The primary purpose of such a project is to store water efficiently, which requires the reservoir basin to be composed of impermeable rock and soil to prevent excessive leakage. While other projects require stable foundations, a reservoir's success depends on the basin's ability to hold water.

223. (B) The manipulation of digital images represented as a grid of pixels on a computer.
A discrete image processing system is primarily concerned with the digital manipulation of images. In this framework, an image is represented as a grid of pixels on a computer, with each pixel containing a numerical value. By applying mathematical algorithms, the system can enhance image quality, correct distortions, and classify features. This computational approach is the standard for processing satellite data.

224. (C) Shape
Interpreters use several primary visual elements to identify objects and geological features on aerial photographs. Shape is one of the most important clues, as many man-made and natural features have characteristic outlines recognized from above. Combined with other elements like size, tone, and texture, shape allows geologists to distinguish between landforms and rock units, providing a fundamental basis for analytical study.

225. (C) A is true but R is false.
GIS is an extremely powerful tool for site selection because it allows for the integration and complex spatial analysis of many different thematic layers. However, the reason provided is false. GIS is designed specifically to perform analysis between different data types and can display multiple layers simultaneously. Its ability to find relationships across diverse datasets is why it is so valuable.

226. (D) Photosynthesis
Energy traveling through the atmosphere interacts with gases and particles through scattering, absorption, and reflection. These processes modify the signal that reaches the sensor. Photosynthesis is a biological process where plants use solar energy to create chemical energy. While related to the Earth's surface, it is not an atmospheric interaction process that affects the properties of electromagnetic radiation as it travels.

227. (A) The stability of the slopes created by road cuts.
When a highway is built through hilly terrain, creating road cuts into hillsides is often necessary. A major geological concern is the stability of the resulting slopes. If the rock or soil is weak or highly jointed, these cuts can trigger landslides that block the road. Geologists must evaluate these risks to design stable slopes and appropriate drainage for highway safety.

228. (D) (i), (ii), and (iii)
A comprehensive flight plan for an aerial survey must specify several critical technical and environmental parameters. This includes the required scale of the photographs, which determines flying height, and the percentages of

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the target. A Synthetic Aperture Radar system is a prime example, as it transmits microwave pulses and records the reflected signal to create an image. This contrasts with passive sensors like LISS cameras, which depend on naturally occurring solar energy. Because active sensors provide illumination, they function in darkness.

263. (C) Gravity dam
A gravity dam is a massive structure designed to resist the horizontal thrust of stored water primarily through its own weight. The downward force of the structure creates friction and shear resistance at the foundation needed to prevent the dam from sliding or overturning. This design requires a strong, competent rock foundation that can support the immense vertical load, ensuring structural stability.

264. (B) The point where the optical axis of the camera lens intersects the film plane, typically found by joining the fiducial marks.
The principal point is the precise geometric center of an aerial photograph. It is defined as the point where the optical axis of the camera lens intersects the plane of the film. On a standard photograph, it is typically located by drawing lines between opposite fiducial marks. This point is a critical reference in photogrammetry, serving as the origin for measuring relief displacement.

265. (B) Have different spectral reflectance and emittance properties.
Remote sensing is an effective tool for identifying rock types because different lithologies possess distinct spectral reflectance and emittance properties. These characteristics are determined by the mineralogical composition and physical structure of each rock unit. By analyzing how different rocks interact with radiation across various wavelengths—from visible to thermal infrared—geologists can distinguish between formations. This information allows for efficient regional geological mapping.

266. (A) Sampled into a grid of pixels and quantized into a set of gray levels or colors.
Discrete image processing is the standard computer-based method for manipulating digital images. In this system, an image is sampled into a finite grid of pixels, and each pixel is assigned a numerical value representing brightness. By applying mathematical algorithms to these numbers, the system can enhance the image or perform automated classification. This digital approach allows for precise and repeatable analysis.

267. (D) Paleontological significance
Engineering rock properties are physical characteristics that directly affect a material's behavior under stress or its interaction with fluids in construction. This includes compressive strength, permeability, and porosity. While paleontological significance—the presence of fossils—is vital for understanding Earth's history, it is not considered an engineering property. Fossils do not typically influence the mechanical strength or hydraulic conductivity of a rock mass.

268. (B) P-3, Q-4, R-2, S-1
Faults and joints represent planes of weakness in a rock mass and act as conduits for water. Permeability is the property that governs the rate of seepage into tunnels or out of reservoirs. Compressive strength measures a rock's ability to support heavy crushing loads, essential for structural foundations. Slope stability is the primary safety concern for highway cuts and mining operations.

269. (B) The flight lines, flying altitude, and camera settings to achieve the desired photo scale and coverage.
In an aerial survey, the flight plan is a detailed guide that ensures accurate and systematic data collection. It specifies the flight lines (path of the aircraft), flying altitude, and camera settings. These factors are carefully chosen to obtain the required photo scale, overlap, and ground coverage. Proper planning ensures complete photographic coverage of the survey area and maintains consistency in the aerial photographs. Therefore, option (B) is correct.

270. (A) Both A and R are true and R is the correct explanation of A.
Photogeology and remote sensing are uniquely suited for studying inaccessible or remote regions where ground-based fieldwork is difficult or expensive. These technologies provide a comprehensive, regional perspective of the terrain from above, allowing geologists to map lithological units and structural features from

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254. (A) Capture, store, analyze, and display geographically referenced information.
The primary function of a Geographic Information System is to provide a comprehensive framework for handling spatial data. This includes the capture, storage, and analysis of all types of geographically referenced information. GIS allows users to integrate diverse datasets into a single system for visualization and complex spatial modeling. This capability is essential for informed decision-making in urban planning and engineering.

255. (B) It creates long shadows that accentuate subtle topographic relief, which may be controlled by underlying geology.
Aerial photographs taken with a low sun angle are often preferred for geological interpretation. The resulting long shadows accentuate subtle variations in terrain topography, making features like low ridges and fault scarps much more visible than under direct overhead light. This enhanced micro-relief provides critical clues to the interpreter about underlying geological structures and landforms, significantly improving the quality of regional mapping.

256. (A) Both A and R are true and R is the correct explanation of A.
Even a perfectly vertical aerial photograph contains geometric distortions if terrain is not flat. Relief displacement, caused by variations in ground elevation, shifts the image of features from true planimetric positions. Because a photograph is a perspective projection, objects at different heights are projected differently onto the film plane. This displacement is inherent in the photography process, explaining this fundamental geometric principle.

257. (A) The strength and stability of the ground material that will support the bridge's foundations (piers and abutments).
The most critical geological consideration for bridge construction is the bearing capacity and stability of foundation materials. Bridge piers concentrate massive structural loads onto small areas of ground. Geologists must ensure that rock or soil at these locations can support forces without excessive settlement. Additionally, the material must resist environmental forces such as scour. Ensuring a stable foundation is essential.

258. (A) Provides information in different parts of the spectrum, allowing for better differentiation of materials like vegetation, soil, and rock types.
Multi-spectral photography offers a major advantage over standard panchromatic imagery by capturing data in several narrow wavelength bands. This additional spectral information allows for better differentiation of surface materials based on their unique signatures. Interpreters can distinguish between various rock types, soil moisture levels, and vegetation health. This capability is essential for accurate geological mapping and environmental monitoring in complex terrains.

259. (B) The overlap between adjacent, parallel flight lines.
Sidelap is a critical parameter in the planning of an aerial survey, referring to the overlap between photographs from adjacent, parallel flight lines. It ensures there are no gaps in coverage across the study area and provides a means to tie different strips of imagery together for mapping. Combined with forward overlap along each flight line, sidelap ensures seamless capture of terrain.

260. (C) Analyzing the spatial correlation between landslide locations, geology, and steep slopes.
A Geographic Information System is designed specifically for performing spatial analysis across multiple datasets. In this example, a GIS can integrate layers of bedrock geology, landslide locations, and slope steepness to analyze spatial correlation between these factors. This allows geologists to identify which combinations of geology and slope are most prone to landslides. This analytical ability is the core power of GIS.

261. (A) Mosaic
A mosaic is the final product of arranging and joining a series of overlapping aerial photographs to form a single, continuous image of a larger geographic area. This technique allows for a regional perspective of the landscape that cannot be captured in a single frame. Mosaics are useful tools for large-scale planning, regional geological studies, and environmental monitoring across various engineering applications.

262. (A) SAR (radar)
Active sensors operate by providing their own source of electromagnetic radiation to illuminate

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279. (B) Ensure full stereoscopic coverage for 3D viewing.
Forward overlap in aerial photography, typically set at sixty percent, is essential for several reasons. Most importantly, it ensures every point on the ground is captured from at least two positions, providing coverage for stereoscopic viewing. This overlap allows the eyes to perceive terrain in three dimensions, which is necessary for accurately identifying landforms and mapping geological structures across the terrain.

280. (B) Emitted thermal energy (heat) from the surface.
A Thermal Infra-Red Line-Scanner is a specialized instrument that measures emitted thermal energy, or heat, from the Earth's surface. Unlike sensors detecting reflected sunlight, TIRLS captures radiant temperature in the thermal infrared region. This capability allows for detection of temperature anomalies, such as geothermal activity or forest fires. Because it measures emitted heat, it is also highly effective for night-time imaging.

281. (B) Assess the stability of slopes, the suitability of foundation materials, and the availability of construction aggregates.
The primary reason for incorporating geology into highway construction is to ensure project safety and performance. Geologists must evaluate the stability of slopes created by road cuts, assess the strength of foundation materials for embankments, and identify nearby sources of gravel for construction aggregate. These assessments help prevent landslides and excessive settlement, which are common causes of maintenance issues in road networks.

282. (B) Inflatable Dam
Standard dam designs used in water storage projects include gravity, arch, and buttress dams, each based on distinct engineering principles. Embankment dams made of earth or rock fill are also common. An inflatable dam" is generally a temporary or small-scale water control device rather than a standard type of large-scale engineering dam meant for significant permanent reservoirs during water management.

283. (C) Two overlapping photographs of the same area taken from different positions.
Stereoscopic viewing requires two overlapping photographs of the same area taken from slightly different positions. This duplication mimics binocular vision, where each eye sees a different perspective. When these two overlapping images are viewed together through a stereoscope, the brain integrates them into a single 3D model. This technique is fundamental to photogeology, as it allows interpreters to perceive relief.

284. (B) Re-radiated at a longer wavelength (as heat).
In remote sensing, when electromagnetic radiation is absorbed by the Earth's surface, it increases the temperature of the material, which then re-radiates that energy at longer wavelengths, primarily in the thermal infrared region. This process is known as thermal emission. Sensing this re-radiated heat is the basis for thermal remote sensing, allowing for the mapping of ground surface temperatures.

285. (D) Acquiring imagery line by line.
Whiskbroom and pushbroom scanners are two mechanical methods for acquiring remote sensing imagery line by line. A whiskbroom scanner uses a rotating mirror to scan the terrain point by point perpendicular to flight. A pushbroom scanner uses a fixed linear array of detectors to capture an entire line of image data simultaneously as the platform moves forward. Both build complete regional images.

286. (B) An uncompacted, water-saturated sand layer (prone to liquefaction).
The least desirable foundation for a heavy structure like a gravity dam is an uncompacted, water-saturated sand layer. Such material has low bearing capacity and is prone to liquefaction during an earthquake, where it suddenly loses strength and behaves like a liquid. This could lead to catastrophic failure. Sound rock like granite is the ideal foundation because of its stability.

287. (B) Delineating fracture traces and permeable rock units that may control groundwater flow.
The primary application of photo geology in hydrogeological studies is to delineate surface features that act as indirect indicators of groundwater. Analysts map fracture traces and joints in bedrock, as these linear features

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imagery. This ability to gather extensive data without constant ground access makes remote sensing a highly efficient mapping tool.

271. (C) Attribute data
In a Geographic Information System, attribute data refers to the non-spatial information that describes the characteristics of geographic features. While spatial data defines a feature's location and shape, the attribute data provides additional context, such as the name of a river or the geological age of a rock unit. This link between geometry and descriptive information is stored in tables.

272. (A) The stability and properties of the ground on which or through which the structure is built.
The most critical geological consideration for any major engineering project, such as a tunnel or bridge, is the stability and physical properties of the ground. Engineers must understand how rock or soil will react to structural loads and environmental stresses. Assessing factors like strength and permeability is essential for designing safe foundations. This understanding ensures that infrastructure remains stable and safe.

273. (B) `Drift` is a lateral shift of the whole aircraft from the flight line, while `crab` is a rotation of the aircraft to counteract wind, causing the photo to be skewed relative to the flight line.
Drift and crab are two distinct phenomena related to aircraft movement during an aerial survey. Drift is the lateral shift of the entire aircraft from its intended flight line caused by crosswinds. Crab is the rotation of the aircraft's longitudinal axis to counteract those winds. While crab helps stay on the flight line, it results in the photographs being skewed or rotated.

274. (A) Microwave
Microwave radiation has the longest wavelengths among the commonly used regions of the electromagnetic spectrum for remote sensing. These wavelengths are used in active systems like Synthetic Aperture Radar. Because they are long, microwaves are not significantly scattered by small atmospheric particles, allowing radar to penetrate clouds and smoke. This capability makes microwave remote sensing an essential tool for all-weather imaging.

275. (D) (i), (ii), and (iii)
Fiducial marks are permanent reference points projected onto the film during an aerial photograph exposure. They are typically located in the corners or at the midpoints of the sides. Their primary purpose is to define the photograph's internal coordinate system and to allow for the precise location of the principal point. All three statements are correct, as they accurately describe essential geometric functions.

276. (A) Its high bearing strength to support the weight of the dam.
A gravity dam is a massive structure that relies on its sheer weight to resist the force of stored water. Therefore, the most important property of the foundation rock is high bearing strength. The underlying material must be able to support the immense vertical pressure without excessive settlement. Ensuring this bearing capacity is critical for the structural integrity and safety of the dam.

277. (B) Landforms such as river terraces, alluvial fans, and glacial moraines.
Interpretation of geomorphology from remote sensing imagery involves the identification and analysis of Earth's surface landforms. Analysts look for characteristic features like river terraces, alluvial fans, and glacial moraines. By observing these features and their spatial relationships from a regional perspective, geologists can reconstruct the processes that have shaped the landscape over time. This analysis is essential for environmental monitoring.

278. (A) Identifying all areas that are within 1 km of a known fault and have a slope greater than 20 degrees.
A primary application of GIS is to perform complex spatial queries to identify areas that meet multiple criteria. In this example, identifying areas within a specific distance of a fault that also have a certain slope steepness is a task perfectly suited for GIS. By overlaying thematic layers, the system can quickly map high-risk zones, supporting landslide hazard assessment and site selection.

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296. (C) Ensures the area is covered systematically and efficiently to meet the project's goals for scale and overlap.
A flight plan is the essential blueprint for an aerial survey, ensuring the target area is covered systematically and efficiently. It specifies technical details such as flying height and aircraft path to achieve required overlap and sidelap percentages. This planning is necessary to produce high-quality imagery that meets geometric and analytical goals. Without a rigorous plan, photography might have gaps.

297. (A) The analysis of landforms and drainage patterns to infer geological processes and history.
In geomorphology, the primary application of remote sensing is the systematic analysis of landforms and drainage patterns to understand surface processes. By observing features from a regional perspective, geologists can identify the results of past events such as glaciation or volcanic activity. This analysis helps reconstruct landscape evolution and is critical for identifying areas prone to hazards like landslides or coastal erosion.

298. (B) Passive systems cannot see through clouds and cannot operate at night without a light source.
The significant disadvantage of a passive optical remote sensing system compared to an active microwave system is its dependence on environmental conditions. Passive sensors rely on naturally available solar energy, meaning they can only acquire imagery during daylight and are limited by cloud cover and smoke. Active microwave systems provide their own source of illumination, allowing them to operate effectively in total darkness.

299. (C) Strong, stable, and able to support a load without failure or excessive deformation.
In engineering geology, the term 'competent rock' refers to a rock mass that possesses sufficient strength and stability to support a structural load without significant failure or excessive deformation. Such rock is usually unweathered and has few structural defects. Competent rock is the ideal foundation for heavy structures like gravity dams and is essential for the stability of tunnel walls and cuts.

300. (B) The ratio of the photographic base to flying height being greater than the human eye base to viewing distance.
Vertical exaggeration in stereoscopic viewing is a perceptual phenomenon caused by the geometry of the viewing system. Specifically, it results when the ratio of the air base to the flying height is significantly larger than the ratio of the human eye base to the distance at which photographs are viewed. This stretches the vertical scale of the 3D model relative to horizontal.

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CHAPTER 08

Economic Geology and Fuel Geology

1. Which of the following refers to the process where ore minerals are formed directly from the crystallization of a cooling magma?
(A) Hydrothermal deposition
(B) Magmatic concentration
(C) Sedimentary precipitation
(D) Contact metasomatism

2. What is the definition of paragenesis" in the context of mineral deposits?
(A) The sequence or order in which minerals are formed in a deposit.
(B) The concentric arrangement of minerals around a central point.
(C) The temperature at which a specific mineral crystallizes.
(D) The process of ore enrichment by surface weathering.

3. Identify the correct statement regarding geological thermometers.
(A) They are physical instruments used to measure the temperature of active volcanoes.
(B) They are exclusively based on the study of fluid inclusions in igneous rocks.
(C) They refer to minerals or mineral assemblages that indicate the temperature of formation.
(D) They measure the current geothermal gradient in an area of ore deposition.

4. Given below are two statements regarding carbonatites.
Statement I : Carbonatites are igneous rocks primarily composed of more than 50% carbonate minerals.
Statement II : They are typically associated with sedimentary limestone formations and lack any economic minerals.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

5. Which of the following is the most appropriate description of a pegmatite?
(A) A fine-grained volcanic rock primarily composed of silica-rich minerals.
(B) A sedimentary rock formed by the high-pressure cementation of gravel.
(C) An exceptionally coarse-grained igneous rock containing rare minerals.
(D) A metamorphic rock formed under conditions of high pressure and heat.

If a mineral deposit is found filling fractures and veins in a host rock, far from the parent igneous body, what process is most likely responsible for its formation?
(A) Magmatic segregation
(B) Hydrothermal deposition
(C) Residual concentration
(D) Sublimation

7. All of the following are primary controls of ore localization EXCEPT:
(A) Structural features like faults and folds.
(B) Lithological variations such as permeable beds.
(C) Proximity to an igneous intrusion.
(D) The distance of the deposit from the Earth's core.

8. Identify the incorrect statement regarding the processes of mineral deposit formation.
(A) Pegmatites are formed through the rapid cooling of low-viscosity lava on the surface.
(B) Sublimation involves direct deposition of minerals from a gaseous state.
(C) Contact metasomatism involves chemical alteration of country rock by magmatic fluids.
(D) Volcano genetic deposits are formed in association with submarine volcanic activity.

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9. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : The process of magmatic concentration can lead to the formation of valuable ore deposits like chromite and nickel sulphides.
Reason (R) : Heavy, early-formed crystals sink and accumulate at the bottom of a magma chamber due to gravity.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

10. The term 'zoning' in mineral deposits refers to:
(A) The spatial distribution of minerals in a systematic pattern.
(B) The administrative classification of active mining districts.
(C) The chronological sequence of mineral crystal formation.
(D) The local enrichment of minerals caused by surface weathering.

11. What is a placer deposit?
(A) A mineral deposit formed by evaporation in a closed basin.
(B) A deposit formed by chemical alteration at the contact of an igneous intrusion.
(C) A vein-type deposit precipitated from hot water solutions.
(D) A concentration of heavy and resistant minerals in sediments, formed by mechanical action.

12. Match the process of mineral deposit formation with its characteristic feature.
List I: (Process)
P. Sedimentary
Q. Residual Concentration
R. Evaporation
S. Supergene Enrichment
List II: (Characteristic Feature)
1. Formation of salt and gypsum beds
2. Weathering and removal of soluble constituents, leaving insoluble ore behind
3. Deposition of minerals like copper and silver just below the water table
4. Formation of banded iron formations
(A) P-4, Q-2, R-1, S-3
(B) P-3, Q-1, R-4, S-2
(C) P-4, Q-3, R-2, S-1
(D) P-2, Q-4, R-1, S-3

13. Identify the correct statement of ore texture and its description.
(A) Colloform texture: Interlocking angular crystals formed simultaneously.
(B) Exsolution texture: Randomly oriented crystals in a fine-grained matrix.
(C) Replacement texture: Presence of pseudomorphs where one mineral replaces another.
(D) Graphic texture: Concentric banding of minerals around a nucleus.

14. Given below are two statements, one is labelled as Cause and the other is labelled as Effect.
Cause: Intense chemical weathering in a tropical climate leaches silica and other soluble components from aluminous rocks.
Effect: Formation of a bauxite deposit.
(A) The Cause and Effect are both correct, and the Cause is the direct reason for the Effect.
(B) The Cause and Effect are both correct, but the Cause is not the direct reason for the Effect.
(C) The Cause is correct, but the Effect is incorrect.
(D) The Cause is incorrect, but the Effect is correct.

15. Identify the incorrect pair of a metallic ore and its common geological association.
(A) Bauxite: Recent volcanic ash deposits
(B) Chromite: Ultramafic igneous rocks
(C) Tin (Cassiterite): Granitic pegmatites and placers
(D) Manganese Nodules: Deep-sea floor sediments

16. Consider the following statements regarding ore microscopy:
1. It primarily involves the study of ore minerals in transmitted light.
2. Textures like exsolution lamellae can provide information about the cooling history of the ore.
3. The reflectivity and color of a mineral are

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key diagnostic properties under reflected light.

Which of the above statements is/are correct?
(A) 1 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2, and 3

17. Given below are two statements.
Statement I : Supergene sulphide enrichment is a process that occurs deep within the Earth's crust under high pressure.
Statement II : This process involves the oxidation of primary sulphide minerals and the re-precipitation of metals at or below the water table to form a richer secondary ore zone.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

18. What is the primary ore mineral of iron, characterized by its red streak?
(A) Hematite
(B) Magnetite
(C) Siderite
(D) Pyrite

19. Arrange the following processes in the typical sequence of formation for a supergene sulphide enrichment deposit, from top to bottom.
1. Zone of Leaching (Gossan)
2. Zone of Oxidized Enrichment
3. Primary Sulphide Zone (Hypogene)
4. Zone of Supergene Sulphide Enrichment

Which of the following represents the correct sequence?
(A) 1, 2, 4, 3
(B) 3, 1, 2, 4
(C) 1, 4, 2, 3
(D) 3, 4, 2, 1

20. The Khetri copper belt is a significant source of copper in India and is located in which state?
(A) Jharkhand
(B) Madhya Pradesh
(C) Karnataka
(D) Rajasthan

21. Which of the following is NOT a primary use of manganese ore?
(A) As an alloy in steel manufacturing to impart toughness.
(B) In the manufacturing of dry-cell batteries.
(C) As a primary source of aluminum metal.
(D) In the chemical industry as an oxidizing agent.

22. What are the macroscopic ingredients of coal, such as Vitrain, Clarain, Durain, and Fusain, collectively known as?
(A) Macerals
(B) Lithotypes
(C) Microlithotypes
(D) Minerals

23. The 'rank' of coal is primarily determined by the:
(A) Amount of sulphur content.
(B) Thickness of the coal seam.
(C) Age of the sedimentary basin.
(D) Percentage of carbon and calorific value.

24. Given below are two statements regarding the origin of petroleum.
Statement I : Petroleum is formed from the thermal maturation of organic matter, primarily of marine origin, buried in sedimentary basins.
Statement II : The transformation of organic matter into petroleum occurs at the Earth's surface under atmospheric pressure.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

25. The process of change in physical and chemical properties of mineral deposits due to reaction with magmatic fluids at the boundary of an igneous intrusion is known as:
(A) Sublimation
(B) Residual concentration
(C) Contact Metasomatism
(D) Placer formation

26. Which of the following is considered a precious mineral?
(A) Diamond
(B) Gypsum
(C) Barite
(D) Graphite

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27. Consider the following minerals:
1. Rock Phosphate
2. Gypsum
3. Potash

Which of these are primarily used in the fertilizer industry?
(A) 1 only
(B) 1 and 2 only
(C) 2 and 3 only
(D) 1, 2, and 3

28. The term for minerals that are essential for the national economy but are not available in sufficient quantity from domestic sources and must be imported is:
(A) Essential minerals
(B) Critical minerals
(C) Abundant minerals
(D) Accessory minerals

29. Identify the correct statement regarding the National Mineral Policy of India.
(A) It aims to discourage private sector participation in mining.
(B) Its primary goal is to promote the export of all raw minerals without processing.
(C) It encourages scientific mining and sustainable mineral development.
(D) It restricts all mining activities to protect the environment completely.

30. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : Anticlines, fault traps, and salt domes are important for the accumulation of petroleum.
Reason (R) : These geological structures provide a sealed configuration that halts the upward migration of oil and gas.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

31. Which microscopic constituent (maceral) of coal is derived from woody tissues and is a major component of bright coal?
(A) Vitrinite
(B) Inertinite
(C) Liptinite
(D) Fusinite

32. What is the primary origin of most coal deposits?
(A) Accumulation of marine plankton within deep anoxic oceanic basins.
(B) Chemical alteration of carbonate rocks by hot and acidic fluids.
(C) Direct crystallization from volatile, carbon-rich magmatic intrusions.
(D) Compaction of terrestrial plant matter in swampy environments.

33. Match the mineral with its primary industrial use.
List I: (Mineral)
P. Graphite
Q. Gypsum
R. Barite
S. Mica
List II: (Industrial Use)
1. Plasterboards and cement manufacturing
2. Electrical insulator and pearlescent pigments
3. Drilling mud and filler
4. Lubricant and pencil lead
(A) P-1, Q-4, R-2, S-3
(B) P-4, Q-1, R-3, S-2
(C) P-4, Q-3, R-1, S-2
(D) P-2, Q-1, R-3, S-4

34. The movement of petroleum from its source rock to a reservoir rock is known as:
(A) Accumulation
(B) Maturation
(C) Migration
(D) Trapping

35. Which of the following is a key characteristic of volcano genetic massive sulphide (VMS) deposits?
(A) Deposits formed in terrestrial environments characterized by arid conditions.
(B) Massive sulphide lenses formed on the seafloor during submarine volcanism.
(C) Ore bodies exclusively composed of high-grade iron and manganese oxides.
(D) Formations resulting from intense chemical weathering and residual enrichment.

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36. An ore body showing textures where one mineral fills the interstices between crystals of another mineral indicates:
(A) Simultaneous crystallization
(B) Later formation of the interstitial mineral
(C) Replacement of the host mineral
(D) Formation by sublimation

37. Which of the following is an example of an oil trap that is stratigraphic in nature?
(A) An anticline trap
(B) A fault trap
(C) A pinch-out or unconformity trap
(D) A salt dome trap

38. The Sukinda valley in Odisha is famous for its large deposits of:
(A) Bauxite
(B) Iron ore
(C) Chromite
(D) Coal

39. Given below are two statements regarding mica.
Statement I : Muscovite is a potassium-rich mica, while phlogopite is a magnesium-rich mica.
Statement II : Due to its perfect cleavage and high thermal conductivity, mica is primarily used as a refractory brick.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

40. The Bailadila range in Chhattisgarh is a prominent source of which ore in India?
(A) Manganese
(B) Copper
(C) Bauxite
(D) High-grade iron ore

41. What is the definition of microlithotypes" in coal petrology?
(A) The individual microscopic organic constituents that make up a coal sample.
(B) Distinct macroscopic layers and bands visible within a natural coal seam.
(C) Maceral associations forming bands with a minimum width of 50 micrometers.
(D) The inorganic mineral matter and trace elements present within the coal.

42. Which of the following is NOT a variety of asbestos?
(A) Chrysotile
(B) Amosite
(C) Crocidolite
(D) Barite

43. Arrange the following varieties of coal in increasing order of their rank.
1. Bituminous
2. Lignite
3. Peat
4. Anthracite

Which of the following represents the correct sequence?
(A) 3, 2, 1, 4
(B) 2, 3, 1, 4
(C) 3, 1, 2, 4
(D) 1, 2, 3, 4

44. Which process leads to the formation of residual deposits like bauxite and lateritic iron ore?
(A) Precipitation from hydrothermal fluids.
(B) Intense chemical weathering and leaching of soluble materials.
(C) Mechanical sorting of heavy minerals by flowing water.
(D) Evaporation of saline water in an arid basin.

45. The Zawar mines in Rajasthan are historically significant for the mining of:
(A) Gold and Silver
(B) Lead and Zinc
(C) Copper and Nickel
(D) Iron and Manganese

46. What is the most significant factor in the National Mineral Policy concerning mineral development?
(A) Maximizing immediate revenue through rapid extraction with no environmental care.
(B) Promoting sustainable development balancing economic growth and environmental protection.
(C) Granting mineral mining rights exclusively to established public sector undertakings.
(D) Prohibiting the export of all mineral resources, including raw and processed ores.

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47. Consider the following statements regarding the origin, mode of occurrence, and association of non-metallic minerals:
1. Asbestos is typically found in association with ultramafic igneous rocks like serpentinite.
2. Gypsum is a sedimentary mineral formed by the evaporation of saline water.
3. High-quality graphite is often found in high-grade metamorphic rocks like gneiss and schist.

Which of the above statements is/are correct?
(A) 1 only
(B) 2 and 3 only
(C) 1 and 2 only
(D) 1, 2, and 3

48. A mineral that is vital for a country's defense industry, for which it is heavily dependent on imports, is classified as:
(A) An essential mineral
(B) A strategic mineral
(C) A semi-precious mineral
(D) An abundant mineral

49. What is the primary use of barite?
(A) As a gemstone
(B) In the manufacturing of electrical insulators
(C) As a weighting agent in drilling muds for the oil and gas industry
(D) As a source of barium metal for fireworks

50. The Tarapur Nuclear Power Station, India's first, is located in which state?
(A) Tamil Nadu
(B) Maharashtra
(C) Rajasthan
(D) Uttar Pradesh

51. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : The process of oxidation and supergene sulphide enrichment can convert a low-grade primary ore deposit into an economically viable one.
Reason (R) : Weathering processes leach metals from the upper parts of an ore body and re-precipitate them in a concentrated zone at or below the water table.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

52. The term gossan" or iron hat" refers to:
(A) An underground zone characterized by supergene sulphide enrichment.
(B) The deep-seated and unweathered primary sulphide ore body.
(C) A barren cap of protective silica formed above an ore deposit.
(D) An iron-rich, porous, and weathered cap over a sulphide ore body.

53. Which of the following is the primary ore of tin?
(A) Wolframite
(B) Scheelite
(C) Cassiterite
(D) Molybdenite

54. Match the ore of the metal with its major producing area in India.
List I: (Ore)
P. Copper
Q. Bauxite
R. Gold
S. Lead-Zinc
List II: (Producing Area)
1. Hutti Mines
2. Zawar Mines
3. Malanjkhand Belt
4. Panchpatmali Deposits
(A) P-3, Q-4, R-1, S-2
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-1, R-4, S-2
(D) P-2, Q-4, R-1, S-3

55. In the context of mineral economics, what does the term mineral concession" refer to?
(A) A financial government subsidy for mineral exploration activities.
(B) The legal right granted by the government to prospect or mine.
(C) A specific tax exemption provided to international mining companies.
(D) The physical process of reclaiming and restoring a mined-out area.

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56. The microscopic constituents of coal, such as vitrinite, liptinite, and inertinite, are collectively known as:
(A) Lithotypes
(B) Macerals
(C) Microlithotypes
(D) Phytoclasts

57. Which Indian state is the largest producer of lignite coal?
(A) Jharkhand
(B) West Bengal
(C) Tamil Nadu
(D) Odisha

58. Given below are two statements regarding petroleum production in India.
Statement I : The Bombay High, located offshore, is India's most significant petroleum-producing field.
Statement II : The productive horizons in Bombay High are primarily found within sandstone reservoirs of the Jurassic age.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

59. The mineral wolframite is an important ore of which metal?
(A) Tin
(B) Tungsten
(C) Molybdenum
(D) Titanium

60. Which of the following is NOT a method of prospecting for atomic minerals?
(A) Scintillometer surveys
(B) Geochemical soil sampling for uranium
(C) Magnetic surveys
(D) Radon gas emanometry

61. Jaduguda mines in Jharkhand are famous for the mining of:
(A) Coal
(B) Bauxite
(C) Iron Ore
(D) Uranium

62. What is the main constituent of natural gas?
(A) Ethane
(B) Propane
(C) Methane
(D) Butane

63. Identify the incorrect statement about the chemical group of a mineral.
(A) Barite - Sulphate
(B) Graphite - Native Element
(C) Gypsum - Oxide
(D) Ochre - Iron Oxide/Hydroxide

64. What is the primary use of ochre?
(A) As a refractory material
(B) In the cement industry
(C) As a fertilizer
(D) As a natural pigment in paints

65. Consider the following statements about the characteristics of fuel minerals:
1. The rank of coal increases with increasing temperature, pressure, and time.
2. Oil traps are necessary to prevent the escape of accumulated petroleum and natural gas.
3. Natural gas is generally found associated with coal deposits and is known as coalbed methane.

Which of the above statements is/are correct?
(A) 1 only
(B) 2 and 3 only
(C) 1 and 2 only
(D) 1, 2, and 3

66. What is the most critical factor for the formation of a commercial petroleum accumulation?
(A) The presence of an organic-rich source rock within the basin.
(B) The presence of a porous and permeable reservoir rock layer.
(C) The presence of an impermeable cap rock to seal the reservoir.
(D) The integration of source, reservoir, trap, and proper timing.

67. The Kolar Gold Fields, a historically significant gold mining center, are located in which state?
(A) Andhra Pradesh
(B) Kerala
(C) Tamil Nadu
(D) Karnataka

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68. The process by which minerals are deposited directly from a volcanic gas or fumarole is called:
(A) Sublimation
(B) Hydrothermal activity
(C) Evaporation
(D) Contact metamorphism

69. Which of the following best describes the texture of an ore?
(A) The shape and size of the ore body as a whole.
(B) The chemical composition of the ore minerals.
(C) The spatial and geometric relationship of minerals within the ore.
(D) The economic value of the ore deposit.

70. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : Pegmatites are economically important as they can host large crystals of valuable minerals like beryl, tourmaline, and mica.
Reason (R) : They are formed from the final, water-and volatile-rich fraction of a cooling granitic magma, which allows for the growth of very large crystals.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

71. Bauxite, the primary ore of aluminum, is formed by which geological process?
(A) Magmatic segregation
(B) Hydrothermal alteration
(C) Residual concentration (lateritization)
(D) Sedimentary evaporation

72. The maceral group 'Liptinite' (or Exinite) in coal is derived from which part of the parent plants?
(A) Woody tissues and stems
(B) Fungal remains and burnt plant material
(C) Plant roots
(D) Spores, cuticles, and resins

73. Arrange the following events in the formation of a petroleum deposit in the correct sequence.
1. Accumulation in a trap
2. Generation from source rock
3. Migration through carrier beds
4. Preservation under a seal rock

Which of the following represents the correct sequence?
(A) 2, 3, 1, 4
(B) 1, 2, 3, 4
(C) 2, 1, 3, 4
(D) 3, 2, 4, 1

74. Ilmenite and rutile, found in the beach sands of Kerala, are important ores of which metal?
(A) Tin
(B) Tungsten
(C) Titanium
(D) Zirconium

75. A concentric zoning pattern of Cu-Pb-Zn sulphides around an igneous intrusive is a classic example of which principle?
(A) Paragenesis
(B) Supergene enrichment
(C) Hydrothermal zoning
(D) Magmatic differentiation

76. Which of the following minerals is essential for the cement industry, where it is used to control the setting time of cement?
(A) Barite
(B) Gypsum
(C) Graphite
(D) Mica

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77. Given below are two statements regarding mineral concession rules in India.
Statement I : The Mineral Concession Rules in India govern the procedure for obtaining prospecting licenses and mining leases.
Statement II : These rules are framed to ensure that mineral resources are explored and exploited in an unscientific and haphazard manner.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

78. The primary difference between a precious and a semi-precious mineral is based on:
(A) Hardness and chemical composition

(B) Rarity, beauty, and market demand
(C) Crystalline structure
(D) Mode of geological occurrence

79. The term 'oil window' refers to the:
(A) The depth and temperature range for oil generation from kerogen.
(B) A specific type of geological structure that traps petroleum.
(C) The peak production timeframe for an active oil extraction well.
(D) A transparent mineral associated with hydrocarbon-rich shales.

80. Identify the correct statement regarding the origin of coal.
(A) Coal is formed primarily from the skeletal remains of marine organisms.
(B) The coalification process involves an increase in moisture and volatiles.
(C) High-grade coals form under higher temperatures than low-grade coals.
(D) All coal deposits were formed during the Carboniferous geological period.

81. The Salem district in Tamil Nadu is known for its deposits of:
(A) Copper
(B) Gold
(C) Magnesite and Iron Ore
(D) Lead-Zinc

82. In ore microscopy, the property of a mineral to show different colors or shades when rotated under plane-polarized reflected light is known as:
(A) Reflectivity
(B) Anisotropism
(C) Bireflectance (or reflection pleochroism)
(D) Internal reflection

83. Match the nuclear power station with the state where it is located.
List I: (Power Station)
P. Kaiga
Q. Kakrapar
R. Rawatbhata
S. Kudankulam
List II: (State)
1. Gujarat
2. Tamil Nadu
3. Karnataka
4. Rajasthan
(A) P-3, Q-1, R-4, S-2
(B) P-1, Q-3, R-2, S-4
(C) P-3, Q-4, R-1, S-2
(D) P-2, Q-1, R-4, S-3

84. What is the fundamental principle behind the formation of placer deposits of gold and tin?
(A) Their high chemical reactivity.
(B) Their low density, allowing them to be transported easily.
(C) Their high specific gravity and resistance to weathering.
(D) Their solubility in river water.

85. Which of the following is NOT a typical feature of a hydrothermal ore deposit?
(A) Occurrence within rock masses as veins, lodes, or fine disseminations.
(B) Presence of common gangue minerals such as crystalline quartz and calcite.
(C) Formation from hot, aqueous solutions circulating through the crust.
(D) Accumulation of heavy minerals by gravity at the base of a magma chamber.

86. The Amjhore deposits in Bihar are well-known for which mineral used in the fertilizer industry?
(A) Rock Phosphate
(B) Potash
(C) Pyrites (for sulphuric acid)
(D) Gypsum

87. Consider the following statements regarding controls of ore deposition:
1. Structural controls like faults and fractures can act as pathways for mineralizing fluids.
2. Chemical controls involve reactions between the ore fluids and favorable host rocks, causing precipitation.
3. Physical controls include changes in temperature and pressure that reduce the solubility of dissolved metals.

Which of the above statements is/are correct?
(A) 1 and 2 only
(B) 3 only
(C) 2 and 3 only
(D) 1, 2, and 3

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88. The most abundant maceral in most coals, responsible for its coherent and bright nature, is:
(A) Fusinite
(B) Sporinite
(C) Vitrinite
(D) Micrinite

89. A bed of rock salt (halite) is a prime example of which type of mineral deposit?
(A) Residual deposit
(B) Placer deposit
(C) Evaporation deposit
(D) Hydrothermal deposit

90. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : The distribution of atomic minerals in India is sporadic and geologically controlled.
Reason (R) : Uranium and Thorium minerals are typically associated with specific rock types such as pegmatites, granites, and ancient sedimentary conglomerates or beach placers.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

91. What is the defining characteristic of a carbonatite"?
(A) It is a sedimentary rock formed from shell fragments.
(B) It is a metamorphic rock rich in graphite.
(C) It is an igneous rock composed of over 50% carbonate minerals.
(D) It is a variety of coal with high carbon content.

92. The Nellore mica belt is a major source of mica in India and is located in which state?
(A) Rajasthan
(B) Jharkhand
(C) Andhra Pradesh
(D) Bihar

93. Identify the incorrect statement about the uses of metallic minerals.
(A) Chromium is primarily used to produce stainless steel.
(B) Lead is extensively used in storage batteries and for radiation shielding.
(C) Beryllium is alloyed with copper to make non-sparking tools.
(D) Tungsten is used as a primary component in manufacturing lightweight aircraft frames.

94. The term productive horizons" in the context of atomic minerals refers to:
(A) The specific geological time periods during which these minerals formed.
(B) Rock layers containing economically viable concentrations of minerals.
(C) The depth within the crust at which nuclear reactions naturally occur.
(D) The most efficient technological methods for generating nuclear power.

95. Which of the following is a primary ore of molybdenum?
(A) Molybdenite
(B) Scheelite
(C) Galena
(D) Sphalerite

96. Which mineral group is the source of ochre" pigments?
(A) Carbonates
(B) Silicates
(C) Iron oxides and hydroxides
(D) Sulphates

97. Given below are two statements regarding mineral deposits.
Statement I : Paragenesis refers to the spatial arrangement of minerals within a deposit.
Statement II : Zoning refers to the chronological sequence of mineral deposition.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

98. The Digboi oilfield, one of India's oldest, is located in which state?
(A) Gujarat
(B) Rajasthan
(C) Assam
(D) Andhra Pradesh

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(B) Monazite (containing Thorium)
(C) Beryl
(D) Pitchblende

118. Which of the following conditions is LEAST favorable for the formation of a rich residual deposit?
(A) Parent rock with valuable minerals.
(B) Arid climate with low rainfall.
(C) Low to moderate topographic relief.
(D) Prolonged period of tectonic stability.

119. Identify the correct pair of a non-metallic mineral and its major occurrence type.
(A) Gypsum: High-grade metamorphic rocks
(B) Asbestos: Recent beach sand deposits
(C) Graphite: Veins in granitic pegmatites
(D) Barite: Vein and replacement deposits, often with sulphides

120. In the context of ore genesis, the term 'control' refers to:
(A) Government regulations on mining.
(B) The factors that influence where and why an ore deposit forms.
(C) The process of stopping the flow of mineralizing fluids.
(D) The economic viability of a deposit.

121. The process of oxidation and supergene sulphide enrichment is most effective for which type of primary ore deposit?
(A) Oxide deposits
(B) Sulphide deposits
(C) Placer deposits
(D) Evaporite deposits

122. Consider the following geological features:
1. Anticline
2. Unconformity
3. Salt Dome
Which of these can act as structural or stratigraphic traps for oil and natural gas?
(A) 1 only
(B) 1 and 3 only
(C) 2 and 3 only
(D) 1, 2, and 3

123. The Singhbhum Shear Zone in Eastern India is a significant metallogenic province, particularly for:
(A) Gold and Silver
(B) Lead and Zinc
(C) Copper and Uranium
(D) Tin and Tungsten

124. The term hypogene" refers to mineralization processes that are:
(A) Caused by descending surface waters.
(B) Related to weathering and erosion.
(C) Caused by ascending fluids from deep within the Earth.
(D) Formed by biological activity at the surface.

125. Which of the following is NOT a significant use of silver?
(A) Photography (historically)
(B) Jewelry and silverware
(C) As a primary structural metal in construction
(D) In electronics for its high conductivity

126. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : Coal rank increases from peat to lignite to bituminous and finally to anthracite.
Reason (R) : This progression reflects an increase in the content of moisture and volatile matter and a decrease in carbon content and calorific value.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

127. The mineral beryl is the most important ore of which metal?
(A) Boron
(B) Bismuth
(C) Barium
(D) Beryllium

128. What best describes the structure of an ore?
(A) The mineralogical composition and chemical properties of the ore.
(B) Large-scale features of an ore body, such as banding or shape.
(C) The microscopic relationship between ore crystals and gangue minerals.
(D) The absolute geological age and origin

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108. The term 'essential minerals' in mineral economics refers to minerals that are:
(A) Minerals that are required only for the production of luxury goods.
(B) Minerals fundamental for the functioning of an industrial society.
(C) Rare minerals that possess high scientific or academic research value.
(D) Plentiful minerals exported to international markets for foreign exchange.

109. Which of the following is an incorrect statement regarding the origin of petroleum?
(A) It requires an anoxic environment to preserve organic matter.
(B) It forms from the thermal maturation of organic-rich source rocks.
(C) The process is geologically rapid, taking only a few thousand years.
(D) It involves the conversion of complex organic molecules (kerogen) into hydrocarbons.

110. Match the metal with its primary ore mineral.
List I: (Metal)
P. Zinc
Q. Lead
R. Copper
S. Aluminium
List II: (Ore Mineral)
1. Bauxite
2. Chalcopyrite
3. Galena
4. Sphalerite
(A) P-3, Q-4, R-1, S-2
(B) P-4, Q-3, R-2, S-1
(C) P-4, Q-2, R-3, S-1
(D) P-1, Q-3, R-2, S-4

111. What does the term geological thermometer" refer to in economic geology?
(A) An instrument to measure subsurface temperatures directly.
(B) A mineral or fluid inclusion property that constrains the temperature of ore formation.
(C) A map showing the geothermal gradient of a region.
(D) The study of heat flow from Earth's interior.

112. The Indian Bureau of Mines (IBM) plays a key role in:
(A) The formal process of granting mineral concessions to private companies.
(B) Promoting the scientific development of national mineral resources.
(C) Directly operating and managing all active mines throughout the country.
(D) Formulating the comprehensive foreign trade policy for mineral exports.

113. What is the primary cause of migration of petroleum and natural gas from source rock to reservoir rock?
(A) Hydrocarbon buoyancy relative to the density of formation water.
(B) Localized magnetic forces generated within the sedimentary basin.
(C) Geothermal temperatures forcing the movement of fluids through rocks.
(D) Tectonic plate movements pushing liquid hydrocarbons toward the surface.

114. Given below are two statements regarding mineral deposit formation.
Statement I : All mineral deposits are formed by magmatic processes.
Statement II : Sedimentary and metamorphic processes also play a crucial role in the formation of various types of ore deposits.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is false, but Statement II is true.
(D) Statement I is true, but Statement II is false.

115. Argentite is an important ore mineral for which metal?
(A) Gold
(B) Platinum
(C) Silver
(D) Nickel

116. Which maceral group in coal is derived from degraded plant material and fungal bodies, and is generally considered non-reactive or 'inert' during coking?
(A) Vitrinite derived from woody tissues.
(B) Liptinite derived from waxy cuticles.
(C) Inertinite derived from degraded material.
(D) Alginite derived from algal remains.

117. The beach sands of Kerala are a major source of which atomic mineral in India?
(A) Uranium

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99. The study of ore minerals using a reflected light microscope is known as:
(A) Petrology
(B) Ore microscopy or Mineragraphy
(C) X-ray diffraction
(D) Geochronology

100. What is the significance of minerals in a national economy?
(A) They have only aesthetic and cultural value.
(B) They serve as a crucial raw material base for industrial development.
(C) They are primarily important for academic research.
(D) Their significance is limited to providing employment in rural areas.

101. Which process involves the alteration of country rock by heat and chemical constituents emanating from an igneous intrusion?
(A) Magmatic concentration
(B) Sedimentary deposition
(C) Contact metasomatism
(D) Residual concentration

102. Arrange the following in the correct chronological order of the processes leading to a placer deposit.
1. Weathering and erosion of a primary lode deposit
2. Concentration of heavy minerals in a river bed
3. Transport of eroded material by a river
4. Deposition of lighter minerals downstream

Which of the following represents the correct sequence?
(A) 1, 3, 2, 4
(B) 3, 1, 2, 4
(C) 1, 2, 3, 4
(D) 2, 1, 4, 3

103. Which of the following is a characteristic texture of ores formed by replacement?
(A) Perfect, euhedral crystals distributed within a fine-grained matrix.
(B) Concentric layers of various minerals exhibiting a colloform habit.
(C) Remnants of host rock texture preserved within the ore mineral.
(D) Parallel intergrowth of two minerals along specific crystallographic planes.

104. Consider the following statements about non-metallic minerals:
1. Graphite is a native element form of carbon, known for its softness and lubricating properties.
2. Barite is a high-density barium sulphate mineral.
3. Chrysotile is the fibrous form of the mineral serpentine and is the most common type of asbestos.

Which of the above statements is/are correct?
(A) 1 and 2 only
(B) 3 only
(C) 2 and 3 only
(D) 1, 2, and 3

105. The Panna belt in Madhya Pradesh is famous for the occurrence of which precious mineral?
(A) Ruby
(B) Sapphire
(C) Diamond
(D) Emerald

106. In coal terminology, what are lithotypes"?
(A) The individual organic constituents derived from microscopic plant parts.
(B) The inorganic mineral impurities found naturally within a coal sample.
(C) Visually distinct macroscopic bands and layers found within coal seams.
(D) The overall rank, grade, or thermal maturity of the sampled coal deposit.

107. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : Hydrothermal solutions are considered a major agent for the formation of many metallic ore deposits, such as copper, lead, and zinc.
Reason (R) : Hot aqueous fluids are effective solvents that can transport metals leached from a magma or country rock and deposit them in response to changes in temperature, pressure, or chemical environment.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

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timeframe of the ore deposit.

129. Match the ore deposit type with its classic mineralogical example.
List I: (Deposit Type)
P. Magmatic Segregation
Q. Hydrothermal Vein
R. Residual Concentration
S. Placer
List II: (Example)
1. Gold in river gravels
2. Bauxite on a peneplain
3. Chromite layers in an ultramafic intrusion
4. Quartz-gold veins
(A) P-4, Q-3, R-1, S-2
(B) P-3, Q-4, R-2, S-1
(C) P-3, Q-2, R-4, S-1
(D) P-1, Q-2, R-3, S-4

130. The Rampura-Agucha mine in Rajasthan is one of the world's largest producers of:
(A) Copper
(B) Iron ore
(C) Lead and Zinc
(D) Bauxite

131. The primary purpose of adding limestone (calcium carbonate) in a cement plant is to:
(A) Provide the main source of calcium oxide (lime).
(B) Act as a fuel source.
(C) Control the setting time.
(D) Add color to the final product.

132. What is the defining feature of a volcano genetic deposit?
(A) A deposit formed by the surface weathering of older volcanic rocks.
(B) A deposit with a close spatial relationship to volcanic processes.
(C) A specific mineral body mined from the crater of an active volcano.
(D) A geological formation consisting entirely of natural volcanic glass.

133. Given below are two statements regarding atomic minerals.
Statement I : Atomic minerals are those whose constituents are used to generate nuclear energy.
Statement II : In India, the primary atomic minerals are ores of copper and lead.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

134. Which of the following is considered a 'semi-precious' mineral?
(A) Diamond
(B) Gold
(C) Platinum
(D) Amethyst (a variety of quartz)

135. The future prospects of nuclear power in India are significantly tied to the utilization of its vast reserves of:
(A) Thorium
(B) High-grade bituminous coal
(C) Natural gas
(D) Lithium

136. Which of the following is a key characteristic of a 'strategic' mineral?
(A) A mineral that is abundant and widely available from domestic sources.
(B) A mineral required for defense whose supply is often uncertain.
(C) A mineral with low economic value but significant scientific interest.
(D) A common mineral used primarily in the national construction industry.

137. Which texture in ores is characterized by a net-like" or mesh" appearance, often seen in the alteration of olivine to serpentine?
(A) Graphic texture
(B) Colloform texture
(C) Mesh texture
(D) Replacement texture

138. Identify the incorrect statement regarding the formation of mineral deposits.
(A) Metamorphic processes can create new minerals or concentrate existing ones, like graphite and asbestos.
(B) Sedimentary processes can form deposits through chemical precipitation (evaporites) or mechanical accumulation (placers).
(C) Sublimation is the most common process for the formation of large, bulk-tonnage ore bodies.
(D) Magmatic concentration can form layered

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deposits within igneous intrusions.

139. Which of the following is NOT a major coalfield in India?
(A) Jharia
(B) Raniganj
(C) Talcher
(D) Khetri

140. The process by which organic matter is converted into petroleum through heat and pressure is called:
(A) Migration
(B) Maturation or Catagenesis
(C) Accumulation
(D) Diagenesis

141. The Gandhamardan hills in Odisha are known for their significant deposits of:
(A) Copper
(B) Chromite
(C) Bauxite
(D) Gold

142. What is the primary use of asbestos, stemming from its fibrous nature and heat resistance?
(A) As a fertilizer
(B) In the production of aluminum
(C) As a fireproofing and insulating material
(D) As a pigment in paint

143. Consider the following statements regarding the geology of tin and tungsten:
1. The primary ore of tin is cassiterite (SnO2), and a primary ore of tungsten is wolframite ((Fe,Mn)WO4).
2. Both metals are characteristically associated with granitic intrusions and related pegmatites and hydrothermal veins.
3. Both cassiterite and wolframite are heavy and resistant minerals, allowing them to be concentrated in placer deposits.

Which of the above statements is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 only
(D) 1, 2, and 3

144. The 'gangue' in an ore deposit refers to the:
(A) Commercially valuable minerals.
(B) Economically worthless minerals associated with the ore minerals.
(C) The host rock surrounding the ore body.
(D) The weathered and oxidized portion of the deposit.

145. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : The National Mineral Policy of India emphasizes the need for value addition and mineral processing within the country.
Reason (R) : Exporting finished or semi-finished mineral-based products generates higher revenue and employment compared to exporting raw ores.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

146. Which of the following is the most important use of nickel?
(A) In the manufacturing of stainless steel and other alloys.
(B) As a primary source of nuclear fuel.
(C) In the production of fertilizers.
(D) As a weighting agent in drilling muds.

147. A rock body that is permeable and porous enough to store and transmit petroleum is called a:
(A) Source rock
(B) Seal rock
(C) Reservoir rock
(D) Basement rock

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148. Match the mineral property with its description in ore microscopy.
List I: (Property)
P. Anisotropism
Q. Reflectivity
R. Internal Reflection
S. Hardness
List II: (Description)
1. Light reflected from within a translucent mineral, often brightly colored.
2. Resistance to scratching, observed as the 'polishing hardness' or 'Vickers hardness'.
3. The percentage of light reflected from a

mineral's surface.
4. The change in color or brightness of a mineral when the stage is rotated between crossed polarizers.

(A) P-1, Q-2, R-3, S-4
(B) P-4, Q-3, R-1, S-2
(C) P-4, Q-1, R-3, S-2
(D) P-3, Q-4, R-2, S-1

149. The Cuddapah basin in Andhra Pradesh is known for significant deposits of:
(A) Coal
(B) Petroleum
(C) Barites and Asbestos
(D) Gold

150. What is the fundamental difference between magmatic concentration and contact metasomatism?
(A) Magmatic concentration occurs in magma; metasomatism affects country rock.
(B) Magmatic concentration forms non-metallic ores; metasomatism forms metallic ones.
(C) Magmatic concentration is a low-temperature process; metasomatism is high-temperature.
(D) There is no fundamental difference; the two processes are geological synonyms.

151. Which of these is a metamorphic process that can lead to the concentration of minerals like graphite or garnet?
(A) Regional or contact metamorphism recrystallizing and segregating minerals.
(B) Mechanical sorting in a river.
(C) Evaporation in a closed basin.
(D) Crystallization from a cooling magma.

152. Which of the following is the most important ore of chromium?
(A) Hematite
(B) Chromite
(C) Bauxite
(D) Pyrolusite

153. Given below are two statements regarding coal reserves in India.
Statement I : India has large, high-quality reserves of coking coal.
Statement II : India is heavily dependent on imports of coking coal for its steel industry.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is false, but Statement II is true.
(D) Statement I is true, but Statement II is false.

154. An exsolution texture in an ore, such as chalcopyrite lamellae in bornite, indicates that:
(A) The two minerals crystallized at the same time from the liquid.
(B) The ore formed at a very low temperature.
(C) A solid solution mineral unmixed into two separate phases upon cooling.
(D) One mineral has replaced the other.

155. The Ankleshwar oilfield is a major onshore productive area located in which Indian state?
(A) Assam
(B) Gujarat
(C) Rajasthan
(D) Tamil Nadu

156. All of the following are typically associated with hydrothermal deposits EXCEPT:
(A) Veins and stockworks
(B) Gangue minerals like quartz and calcite
(C) Layered intrusions of chromite
(D) Wall-rock alteration

157. Which of the following is the primary mineral used in the fertilizer industry as a source of potassium?
(A) Sylvite (Potash)
(B) Apatite (Phosphate)
(C) Gypsum
(D) Pyrite

158. The Sandur schist belt in Karnataka is an important source of which two metallic ores?
(A) Copper and Lead
(B) Gold and Silver
(C) Iron and Manganese
(D) Tin and Tungsten

159. Identify the incorrect statement about the chemical group of a mineral.
(A) Graphite: Refractory crucibles
(B) Mica: Electrical insulation
(C) Gypsum: Weighting agent in drilling mud
(D) Barite: Filler in paint and plastics

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secondary sulphides are precipitated.
(C) The uppermost part of the deposit (gossan) where sulphides are altered to oxides and carbonates.
(D) The unaltered host rock.

180. The most important use of manganese in modern industry is:
(A) As a pigment
(B) In the manufacture of fertilizers
(C) As an alloy in steelmaking
(D) In nuclear reactors

181. Consider the following statements regarding atomic minerals in India:
1. Uranium deposits are found in the Singhbhum Shear Zone in Jharkhand.
2. Thorium is primarily sourced from monazite found in the beach sands of Kerala and Tamil Nadu.
3. The Department of Atomic Energy (DAE) is responsible for the prospecting and development of atomic minerals.

Which of the above statements is/are correct?
(A) 1 and 2 only
(B) 3 only
(C) 2 and 3 only
(D) 1, 2, and 3

182. A mineral deposit formed by the accumulation of shells and other organic remains on the seafloor, which are later lithified, is an example of a:
(A) Biogenic sedimentary deposit
(B) Hydrothermal deposit
(C) Residual deposit
(D) Placer deposit

183. The Malanjkhand copper deposit in Madhya Pradesh is a large, low-grade deposit of which type?
(A) Volcano genetic massive sulphide
(B) Porphyry copper deposit
(C) Sedimentary exhalative (SEDEX)
(D) Magmatic sulphide deposit

184. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : The study of paragenetic sequence is crucial in understanding the evolution of an ore deposit.
Reason (R) : It reveals the changing physical and chemical conditions of the ore-forming fluid over time by showing the order in which different minerals were deposited.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

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185. The Cambay Basin in Gujarat is a major petroliferous basin in India known for its:
(A) Onshore oil and gas fields
(B) Offshore deep-water gas fields
(C) Coalbed methane production
(D) Heavy oil sands

186. Which of the following is NOT a characteristic of a critical" mineral?
(A) It is essential in use.
(B) Its supply is at risk of disruption.
(C) It is abundantly produced domestically.
(D) There are no easy substitutes for it.

187. Match the term related to fuel geology with its definition.
List I: (Term)
P. Source Rock
Q. Reservoir Rock
R. Cap Rock
S. Trap
List II: (Definition)
1. A porous and permeable rock body that holds hydrocarbons.
2. A configuration of rocks that confines hydrocarbons and prevents their escape.
3. A fine-grained organic-rich sedimentary rock that generates hydrocarbons upon maturation.
4. An impermeable rock that overlies a reservoir and prevents upward migration.
(A) P-3, Q-1, R-4, S-2
(B) P-1, Q-3, R-2, S-4
(C) P-3, Q-4, R-1, S-2
(D) P-2, Q-1, R-4, S-3

188. Which process is responsible for the formation of lateritic nickel deposits?
(A) Magmatic segregation in a basaltic flow.

fracture)
4. Black, charcoal-like, and friable (soft and powdery)

(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-2, R-1, S-4
(C) P-3, Q-4, R-1, S-2
(D) P-2, Q-1, R-4, S-3

169. What is the significance of a seal" or cap rock" in a petroleum system?
(A) It is the rock from which the petroleum is generated.
(B) It is a porous rock that stores the petroleum.
(C) It is an impermeable rock that prevents the upward escape of petroleum.
(D) It is the basement rock on which the sedimentary basin rests.

170. Which state in India is the leading producer of mica?
(A) Rajasthan
(B) Bihar
(C) Jharkhand
(D) Andhra Pradesh

171. Which of the following best defines a mineral policy"?
(A) A formal scientific paper describing a newly discovered mineral species.
(B) A set of government principles and strategies for managing minerals.
(C) A corporate management strategy designed for mineral exploration firms.
(D) A regional geological map showing the location of mineral occurrences.

172. The presence of ilmenite in a magmatic deposit would suggest an ore of which metals?
(A) Iron and Titanium
(B) Iron and Chromium
(C) Iron and Nickel
(D) Iron and Manganese

173. Given below are two statements regarding placer deposits.
Statement I : Placer deposits are concentrations of light minerals with low chemical resistance.
Statement II : They are formed by mechanical concentration processes, primarily by water, which sorts minerals based on their specific gravity.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is false, but Statement II is true.
(D) Statement I is true, but Statement II is false.

174. The Hutti Gold Mine" is one of the major producers of gold in India and is located in:
(A) Andhra Pradesh
(B) Tamil Nadu
(C) Karnataka
(D) Kerala

175. Which variety of coal has the highest carbon content and calorific value?
(A) Peat
(B) Lignite
(C) Bituminous
(D) Anthracite

176. Which of the following is a sedimentary process of mineral deposit formation?
(A) Contact metasomatism
(B) Formation of Banded Iron Formations (BIFs)
(C) Formation of pegmatites
(D) Magmatic segregation

177. Identify the correct statement regarding the origin of natural gas.
(A) It forms at much lower temperatures and pressures than liquid crude oil.
(B) It can be thermogenic, formed deep within the earth, or biogenic.
(C) It is exclusively found as a dissolved gas within underground crude oil.
(D) It is a solid hydrocarbon variety that migrates slowly through rocks.

178. The primary use of graphite is related to its properties of:
(A) High hardness and abrasive quality.
(B) High density and use as a weighting material.
(C) High electrical conductivity and high melting point (refractoriness).
(D) Perfect cleavage and transparency.

179. The term oxide zone" in a weathered sulphide deposit refers to the:
(A) Deep, un-oxidized primary ore.
(B) Zone just below the water table where

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160. What is the primary mechanism for the formation of bedded salt (halite) and gypsum deposits?
(A) Hydrothermal precipitation
(B) Magmatic differentiation
(C) Solar evaporation of seawater or saline lake water
(D) Residual weathering

161. Arrange the following in the order they would be encountered from the surface downwards in a typical weathered sulphide deposit.
1. Deposition of late-stage gangue minerals like calcite.
2. Fracturing of the host rock.
3. Deposition of early, high-temperature ore minerals like pyrite.
4. Deposition of lower-temperature ore minerals like galena and sphalerite.

Which of the following represents the correct sequence?
(A) 2, 3, 4, 1
(B) 1, 2, 3, 4
(C) 2, 1, 3, 4
(D) 3, 4, 1, 2

162. Consider the following statements about India's mineral position:
1. India has large reserves of high-grade iron ore and bauxite.
2. India is largely self-sufficient in copper, lead, and zinc.
3. India possesses one of the largest reserves of thorium in the world, primarily in monazite sands.

Which of the above statements is/are correct?
(A) 1 and 2 only
(B) 1 and 3 only
(C) 2 and 3 only
(D) 1, 2, and 3

163. The Narora Atomic Power Station is located in which state of India?
(A) Maharashtra
(B) Uttar Pradesh
(C) Gujarat
(D) Rajasthan

164. What is the most common geological setting for asbestos deposits?
(A) In association with serpentinized ultramafic rocks.
(B) In evaporite sedimentary sequences.
(C) In recent, unconsolidated beach sands.
(D) In low-rank coal seams.

165. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : The study of fluid inclusions in minerals can provide information about the temperature and composition of ore-forming fluids.
Reason (R) : Fluid inclusions are tiny, trapped samples of the fluid from which the host mineral crystallized.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

166. A colloform texture, characterized by spherical or reniform (kidney-shaped) aggregates with internal concentric banding, is indicative of:
(A) Slow mineral crystallization occurring at great depths within the crust.
(B) Deposition from a colloidal solution or gel at low temperatures.
(C) Replacement of a pre-existing mineral through hydrothermal processes.
(D) Unmixing of a solid solution phase during gradual atmospheric cooling.

167. Which of the following is the main ore for lead?
(A) Sphalerite
(B) Galena
(C) Chalcopyrite
(D) Cinnabar

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168. Match the lithotype of coal with its macroscopic characteristic.
List I: (Lithotype)
P. Vitrain
Q. Clarain
R. Durain
S. Fusain
List II: (Characteristic)
1. Dull, hard, and granular
2. Bright, with a silky sheen, and finely banded
3. Brilliant, black, and glassy (conchoidal

(B) Hydrothermal deposition from black smokers.
(C) Intense tropical weathering of ultramafic rocks.
(D) Mechanical concentration in river sands.

189. What is the key difference between vitrain and fusain, the lithotypes of coal?
(A) Vitrain is dull, while fusain is bright and glassy.
(B) Vitrain is derived from woody tissue, while fusain is charcoal-like, often from fires.
(C) Vitrain has low carbon content, while fusain has high carbon content.
(D) Vitrain is a maceral, while fusain is a lithotype.

190. What is the most common use of gypsum in agriculture?
(A) As a primary source of nitrogen for nutrient-depleted soil types.
(B) As a soil conditioner providing essential calcium and sulfur minerals.
(C) As an effective chemical pesticide to control common crop insects.
(D) As a corrective agent used to increase the overall acidity of soil.

191. The Kudremukh deposits in Karnataka are famous for:
(A) Bauxite
(B) Magnetite iron ore
(C) Gold
(D) Copper

192. Given below are two statements regarding ore discoveries.
Statement I : All ore deposits are located at the surface and are easily discoverable.
Statement II : Many ore deposits are concealed or 'blind' and require sophisticated geological, geophysical, and geochemical prospecting methods for discovery.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is false, but Statement II is true.
(D) Statement I is true, but Statement II is false.

193. The Keonjhar district in Odisha is part of a major iron ore belt known as:
(A) Bellary-Hospet belt
(B) Dalli-Rajhara range
(C) Bonai-Keonjhar belt
(D) Singhbhum belt

194. Which of the following metals is known for being alloyed with copper to produce brass?
(A) Zinc
(B) Tin
(C) Nickel
(D) Aluminium

195. In ore microscopy, what does 'anisotropism' reveal about a mineral?
(A) Its absolute resistance to scratching and physical polishing.
(B) Whether it is optically isotropic or possesses anisotropic properties.
(C) Its precise chemical composition and elemental trace components.
(D) Its measured specific gravity relative to common gangue minerals.

196. Which Indian geological formation is the primary host for most of the country's coal reserves?
(A) The Deccan Traps
(B) The Gondwana Supergroup
(C) The Cuddapah Supergroup
(D) The Siwalik Group

197. The term paragenetic sequence" is best defined as:
(A) The zoning of minerals in a deposit.
(B) The order of formation of minerals over time in an ore deposit.
(C) The classification of minerals based on their economic value.
(D) The study of the crystal structure of ore minerals.

198. The Balaghat district of Madhya Pradesh is the leading producer of which mineral in India?
(A) Iron ore
(B) Bauxite
(C) Manganese ore
(D) Coal

199. What type of ore deposit is formed when a metal-bearing fluid reacts with and replaces a favorable host rock, like limestone?
(A) A skarn or contact metasomatic deposit.

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(B) Clarain with a silky banded sheen.
(C) Durain composed of the inertinite group.
(D) Fusain resembling charcoal and powder.

222. The term syngenetic" describes a mineral deposit that formed:
(A) At the same time as the host rock.
(B) Much later than the host rock.
(C) Through weathering of the host rock.
(D) Through replacement of the host rock.

223. Consider the following geological processes:
1. Fractional crystallization and gravity settling in a magma chamber.
2. Precipitation of minerals from hot, aqueous fluids circulating in rock fractures.
3. Mechanical sorting of heavy, resistant minerals in a river system.

Which of these describes the formation of magmatic concentration, hydrothermal, and placer deposits, respectively?
(A) 1, 2, 3
(B) 2, 1, 3
(C) 3, 1, 2
(D) 1, 3, 2

224. The term 'epigenetic' describes a mineral deposit that formed:
(A) At the same time as the host rock.
(B) After the formation of its host rock.
(C) By biological processes.
(D) By evaporation of sea water.

225. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : The presence of certain minerals like tourmaline and topaz in a vein deposit suggests a close association with a granitic intrusion.
Reason (R) : These minerals are rich in boron and fluorine, volatiles that are typically concentrated in the late-stage fluids derived from granitic magmas.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

226. What is the role of bacteria in the formation of some mineral deposits, such as pyrites or bog iron ores?
(A) They physically transport the mineral grains into a concentrated place.
(B) They act as a localized heat source required for mineral formation.
(C) They mediate chemical reactions causing the mineral precipitation.
(D) They have no biological or chemical role in the mineral formation.

227. In the context of India's mineral concession rules, what is a Mining Lease"?
(A) A license to explore for minerals in a given area.
(B) A lease to undertake mining operations and extract minerals.
(C) A permit to transport minerals from the mine.
(D) An environmental clearance for a mining project.

228. Match the ore mineral with its correct chemical formula.
List I: (Ore Mineral)
P. Hematite
Q. Chalcopyrite
R. Galena
S. Sphalerite
List II: (Chemical Formula)
1. PbS
2. ZnS
3. Fe_2O_3
4. $CuFeS_2$
(A) P-3, Q-4, R-1, S-2
(B) P-4, Q-3, R-2, S-1
(C) P-3, Q-1, R-4, S-2
(D) P-2, Q-4, R-1, S-3

229. The Neyveli deposits in Tamil Nadu are India's prime source of:
(A) Anthracite
(B) Bituminous coal
(C) Lignite
(D) Petroleum

230. The Chikmagalur" district in Karnataka is well-known for its deposits of:
(A) Copper
(B) Bauxite

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209. The term 'rock oil' is another name for:
(A) Natural Gas
(B) Coal
(C) Petroleum
(D) Kerogen

210. Which of the following is an ore of Beryllium?
(A) Beryl
(B) Bauxite
(C) Barite
(D) Bornite

211. The process involving the downward percolation of acidic surface waters, leaching of metals, and their re-precipitation at the water table is:
(A) Magmatic segregation
(B) Contact metamorphism
(C) Oxidation and supergene sulphide enrichment
(D) Hydrothermal replacement

212. Given below are two statements regarding oil exploration in India.
Statement I : The Krishna-Godavari (KG) Basin is a major prospective area for deep-water gas reserves in India.
Statement II : All petroleum exploration in India is carried out exclusively by the public sector company ONGC.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

213. A 'skarn' is a type of ore deposit formed by:
(A) Contact metasomatism involving carbonate-rich host rock bodies.
(B) Magmatic segregation within a large underground magma chamber.
(C) Residual weathering processes occurring in humid tropical zones.
(D) Mechanical deposition in a high-energy river placer environment.

214. The main economic use of the mineral apatite is:
(A) As a gemstone
(B) In the manufacture of phosphate fertilizers
(C) As an abrasive
(D) As a refractory material

215. The 'Gondite series' in Madhya Pradesh and Maharashtra are metamorphosed sedimentary rocks rich in which metal?
(A) Iron
(B) Copper
(C) Manganese
(D) Gold

216. Which of the following is the best example of a structural trap for petroleum?
(A) An anticline
(B) A pinch-out of a sandstone layer
(C) An unconformity
(D) A porous reef limestone enclosed in shale

217. Identify the mineral that is NOT typically used in the cement industry.
(A) Limestone
(B) Clay/Shale
(C) Gypsum
(D) Mica

218. The Tosham hill area in Haryana is known for the mineralization of which metal?
(A) Copper
(B) Gold
(C) Tin
(D) Lead

219. The 'cut-off grade' of an ore is the:
(A) Highest grade of mineral found in the deposit.
(B) Average grade of the entire mineral deposit.
(C) Minimum grade required for a mineral to be economically mineable.
(D) Grade of the waste rock or gangue.

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220. What is the primary method of prospecting for buried sulphide ore bodies that may not have a surface expression?
(A) Direct visual observation
(B) Panning in nearby streams
(C) Geophysical methods like Induced Polarization (IP) and Electromagnetics (EM)
(D) Studying the fossil content of the rocks

221. Which type of coal lithotype is known to be very hard, dull, and composed primarily of the maceral group inertinite?
(A) Vitrain derived from woody tissue.

283. Consider the following statements related to the mineral economics of India:
1. The Mines and Minerals (Development and Regulation) Act is the principal legislation governing mining in India.
2. The concept of 'strategic minerals' includes those vital for national defense.
3. Mineral concession rules provide the framework for granting rights for prospecting and mining.

Which of the above statements is/are correct?
(A) 1 and 2 only
(B) 3 only
(C) 2 and 3 only
(D) 1, 2, and 3

284. The 'Dalli-Rajhara' mines in Chhattisgarh are a major captive source of which ore for the Bhilai Steel Plant?
(A) Manganese Ore
(B) Iron Ore
(C) Coal
(D) Limestone

285. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : The study of ore textures under a microscope can help in designing mineral processing and metallurgical extraction techniques.
Reason (R) : Textures reveal the size, shape, and intergrowth relationships of ore and gangue minerals, which determines how the ore must be crushed and separated.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

286. What is the defining characteristic of a 'residual' mineral deposit?
(A) A deposit that is transported and later deposited by flowing water.
(B) A deposit concentrated in-situ by weathering and removal of minerals.
(C) A deposit formed by direct precipitation from hot volcanic gas fumes.
(D) A mineral body that crystallizes from a cooling underground magma chamber.

287. Which of the following is the most important ore of aluminium?
(A) Cryolite
(B) Corundum
(C) Kaolinite
(D) Bauxite

288. Match the term with its most appropriate description.
List I: (Term)
P. Paragenesis
Q. Zoning
R. Syngenetic
S. Epigenetic
List II: (Description)
1. Deposit formed after the host rock
2. Spatial distribution pattern of minerals
3. Temporal sequence of mineral formation
4. Deposit formed contemporaneously with the host rock
(A) P-3, Q-2, R-4, S-1
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-4, R-2, S-1
(D) P-2, Q-3, R-1, S-4

289. The presence of 'boxwork' structures in a gossan is often an indicator of:
(A) The type of primary sulphide mineral that was originally present.
(B) The age of the deposit.
(C) The temperature of formation.
(D) The presence of petroleum underneath.

290. What is the fundamental principle of the 'National Mineral Policy'?
(A) To maximize the export of national mineral resources in their raw form.
(B) To develop mineral resources in a sustainable and scientific manner.
(C) To reserve all national mining and extraction activities for the government.
(D) To stop all current mining activities to completely preserve natural resources.

291. Which of the following is NOT an atomic mineral?
(A) Pitchblende
(B) Monazite
(C) Beryl

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(C) Iron Ore
(D) Gold

231. What is the primary physico-chemical characteristic that defines the rank of coal?
(A) The percentage of ash content
(B) The percentage of fixed carbon and volatile matter
(C) The thickness of the seam
(D) The sulphur content

232. Given below are two statements regarding gold.
Statement I : Gold is often found in its native form in nature.
Statement II : Due to its high density and chemical inertness, gold is frequently concentrated in placer deposits.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

233. Which of the following is NOT a significant mineral product of the state of Rajasthan?
(A) Lead and Zinc
(B) Gypsum and Asbestos
(C) Copper
(D) High-grade coking coal

234. The association of cassiterite (tin ore) with granite, pegmatites, and high-temperature quartz veins is a classic example of what type of mineralization?
(A) Sedimentary
(B) Pneumatolytic to hydrothermal
(C) Residual
(D) Evaporitic

235. The mineral resources of the ocean floor, such as manganese nodules, are examples of which type of deposit?
(A) Hydrothermal deposits
(B) Hydrogenous/Authigenic sedimentary deposits
(C) Placer deposits
(D) Residual deposits

236. What is the primary role of the Mineral Conservation and Development Rules (MCDR) in India?
(A) To fix and regulate the market price of extracted national minerals.
(B) To ensure scientific mining with a focus on environmental conservation.
(C) To formally grant prospecting licenses to qualified exploration firms.
(D) To promote the international export of raw, unprocessed mineral ores.

237. The 'Bastar Craton' in Central India is known for its rich deposits of:
(A) Petroleum and Natural Gas
(B) Iron ore, Tin, and Bauxite
(C) Potash and Gypsum
(D) Lignite coal

238. Which of the following is the most important ore of tungsten?
(A) Wolframite and Scheelite
(B) Cassiterite
(C) Bauxite
(D) Ilmenite

239. The transition from organic matter to kerogen and then to oil and gas is primarily controlled by:
(A) The type of trap structure.
(B) The porosity of the reservoir rock.
(C) Temperature and duration of burial.
(D) The salinity of the formation water.

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240. The term 'ore' is best defined as:
(A) Any geological rock body that contains a specific mineral species.
(B) A natural mineral from which a valuable part can be extracted at a profit.
(C) A term used as a synonym for a single, well-formed mineral crystal.
(D) The economically worthless part of a larger, identified mineral deposit.

241. What is the principal use of tin?
(A) As a primary structural metal in the large-scale construction industry.
(B) In the specialized manufacturing of optical glass and solar panels.
(C) As a coating for steel and in alloys such as solder and bronze.
(D) As a primary nuclear fuel source for next-generation power plants.

242. Consider the following locations in India:

1. Jaduguda
2. Khetri
3. Sukinda

These locations are famous for which ores, respectively?
(A) Copper, Uranium, Chromite
(B) Uranium, Copper, Chromite
(C) Chromite, Copper, Uranium
(D) Uranium, Chromite, Copper

243. Why is graphite used as a lubricant?
(A) Its layered structure with weak bonds allows layers to slide easily.
(B) It is extremely hard and functions as a high-performance abrasive.
(C) It exists as a liquid state at standard room temperature conditions.
(D) It reacts chemically with metal surfaces to eliminate friction forces.

244. The Rajasthan Atomic Power Station is located near which city?
(A) Jaipur
(B) Jodhpur
(C) Kota (at Rawatbhata)
(D) Udaipur

245. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : The Damodar Valley region in eastern India is known as the Ruhr of India."
Reason (R) : This region is extremely rich in coal and is home to a large number of industries, similar to the Ruhr industrial region in Germany.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

246. What type of geological environment is required for the genesis of coal?
(A) A swampy or deltaic environment with rapid plant material burial.
(B) A deep marine environment characterized by high oceanic oxygen levels.
(C) A desert environment with high rates of evaporation and salt buildup.
(D) A high-grade metamorphic environment with extreme crustal pressure.

247. The mineral 'pitchblende' is the primary ore of which element?
(A) Thorium
(B) Uranium
(C) Beryllium
(D) Molybdenum

248. Match the geological process with the resulting mineral deposit.
List I: (Process)
P. Contact Metasomatism on Limestone
Q. Residual weathering in tropics
R. Evaporation of brine
S. Magmatic segregation of sulphides
List II: (Deposit)
1. Bauxite
2. Nickel-Copper sulphides at Sudbury
3. Rock Salt (Halite)
4. Skarn deposit (e.g., Tungsten)
(A) P-1, Q-4, R-2, S-3
(B) P-4, Q-1, R-3, S-2
(C) P-4, Q-3, R-1, S-2
(D) P-2, Q-1, R-3, S-4

249. Which of the following is the most important use of manganese in modern industry?
(A) All mineral deposits are directly formed from magma.
(B) Magma can be the source of heat, fluids, and metals for a wide variety of ore deposits.
(C) Magma only destroys pre-existing mineral deposits.
(D) There is no relationship between magma and mineral deposits.

250. Which of the following is a key component of India's three-stage nuclear power programme?
(A) The use of imported uranium in the first stage.
(B) The eventual use of thorium-based fuel in the third stage.
(C) The exclusive reliance on fast breeder reactors in all stages.
(D) The phasing out of all nuclear power by 2050.

251. The wall rock alteration" associated with hydrothermal ore deposits refers to:
(A) The physical collapse of the rock mass

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surrounding a mineral vein.
(B) Chemical and mineralogical changes in host rock due to ore fluids.
(C) The natural process of surface weathering on the visible rock outcrop.
(D) The distinctive color banding observed within the mineralized ore vein.

252. Given below are two statements regarding the National Mineral Policy.
Statement I : India's National Mineral Policy promotes a 'zero-waste' mining approach.
Statement II : This involves maximizing the extraction of the main mineral while completely ignoring the associated low-grade ores and gangue minerals.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

253. The Byrapur chromite deposits are located in which Indian state?
(A) Odisha
(B) Karnataka
(C) Jharkhand
(D) Tamil Nadu

254. What is the most likely origin of native silver deposits found in veins with cobalt-nickel arsenides?
(A) Placer concentration
(B) Residual enrichment
(C) Low to moderate temperature hydrothermal deposition
(D) Magmatic segregation

255. The term 'lithotypes' in coal studies refers to:
(A) Microscopic organic components
(B) Macroscopic, visually distinct bands of coal
(C) Inorganic mineral matter
(D) The overall rank of the coal

256. Which of the following processes is NOT a primary mechanism of ore genesis?
(A) Metamorphic remobilization
(B) Hydrothermal deposition
(C) Fossilization
(D) Magmatic concentration

257. In India, occurrences of molybdenum are often associated with the ores of:
(A) Iron and Manganese
(B) Uranium and Copper
(C) Gold and Silver
(D) Aluminium

258. Identify the incorrect statement concerning mineral economics.
(A) A country rich in mineral resources always has a highly developed economy.
(B) Mineral policies aim to regulate mining for sustainable growth.
(C) Strategic minerals are crucial for national security.
(D) The value of a mineral deposit depends on grade, tonnage, and market prices.

259. What is the difference between a maceral and a microlithotype?
(A) A maceral is a microscopic constituent, while a microlithotype is a macroscopic band.
(B) A maceral is an individual organic particle, while a microlithotype is a characteristic association of macerals.
(C) A maceral is inorganic, while a microlithotype is organic.
(D) There is no difference; the terms are interchangeable.

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260. The process of supergene enrichment is responsible for creating a secondary zone of enriched:
(A) Iron oxides
(B) Sulphides (e.g., chalcocite, covellite)
(C) Carbonates
(D) Silicates

261. The Khondalite Group" of rocks in the Eastern Ghats are the parent rocks for which major ore deposit in India?
(A) Copper at Malanjkhand
(B) Bauxite in Odisha and Andhra Pradesh
(C) Gold at Kolar
(D) Uranium at Jaduguda

262. Consider the following statements regarding the geology of lead and zinc:
1. Galena (PbS) and Sphalerite (ZnS) are their respective primary ore minerals.

2. They commonly occur together in hydrothermal vein and replacement deposits.
3. Major Indian deposits are located in the Zawar and Rampura-Agucha belts of Rajasthan.

Which of the above statements is/are correct?
(A) 1 and 2 only
(B) 3 only
(C) 2 and 3 only
(D) 1, 2, and 3

263. The primary feature used to distinguish between different asbestos minerals like chrysotile and crocidolite is their:
(A) The observed color of the minerals in hand specimen.
(B) Difference in chemical composition and crystal structure.
(C) The natural geological association with gold deposits.
(D) The relative hardness of the fibrous mineral strands.

264. What is the main objective of studying ore textures and structures?
(A) To determine the absolute geological age of the mineral deposit.
(B) To understand the history of ore formation and later deformation.
(C) To calculate the total economic tonnage of the identified ore body.
(D) To assign a formal scientific name to the specific mineral deposit.

265. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : The Bombay High is India's most important offshore oilfield.
Reason (R) : The petroleum is trapped in a large dome-like anticline structure in Miocene limestone reservoirs.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

266. Which of the following is the most important use of tungsten?
(A) In the manufacturing of stainless steel and other alloys.
(B) As a primary source of nuclear fuel.
(C) In the production of fertilizers.
(D) As a weighting agent in drilling muds.

267. The Jharia coalfield, known for its prime coking coal, is located in which state?
(A) West Bengal
(B) Odisha
(C) Bihar
(D) Jharkhand

268. Match the mining region with its primary mineral product.
List I: (Region)
P. Singhbhum
Q. Nellore
R. Panna
S. Neyveli
List II: (Mineral)
1. Lignite
2. Diamond
3. Mica
4. Copper/Uranium
(A) P-1, Q-2, R-3, S-4
(B) P-4, Q-3, R-2, S-1
(C) P-4, Q-2, R-3, S-1
(D) P-3, Q-4, R-1, S-2

269. The 'oil window' concept in petroleum geology relates to:
(A) The specific geographical area where liquid oil is commonly found.
(B) The temperature range where oil is generated from kerogen source rock.
(C) The specialized technology used to visually observe oil in a reservoir.
(D) The specific timeframe during which a newly drilled oil well is productive.

270. Which of the following is an example of a syngenetic ore deposit?
(A) A quartz vein cutting across pre-existing layers of metamorphic slate.
(B) A manganese ore layer within a metamorphosed sedimentary sequence.
(C) A skarn deposit formed at the contact of a granitic body and limestone.

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(D) A copper deposit enriched through secondary supergene weathering.

271. Which property of mica makes it invaluable for the electronics industry?
(A) Its high specific gravity.
(B) Its properties as an excellent electrical and thermal insulator.
(C) Its softness and greasy feel.
(D) Its metallic luster.

272. Given below are two statements regarding placer deposits.
Statement I : Placer deposits are formed by chemical precipitation from seawater.
Statement II : They are concentrations of heavy, durable minerals like gold, tin, and diamond, formed by gravity sorting in streams or on beaches.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is false, but Statement II is true.
(D) Statement I is true, but Statement II is false.

273. The Debari Zinc Smelter, one of the largest in India, is located in which state?
(A) Jharkhand
(B) Rajasthan
(C) Andhra Pradesh
(D) Odisha

274. The term 'macerals' in coal petrology is analogous to what term in the study of inorganic rocks?
(A) Textures
(B) Structures
(C) Minerals
(D) Fossils

275. Which of the following is a key physical control on ore deposition from a hydrothermal fluid?
(A) The political boundary of the country.
(B) A sudden drop in pressure or temperature causing supersaturation.
(C) The presence of fossils in the host rock.
(D) The color of the host rock.

276. The occurrence of beryl, spodumene, and lepidolite in an extremely coarse-grained igneous rock is characteristic of a:
(A) Basalt flow
(B) Carbonatite
(C) Granite pegmatite
(D) Gabbroic intrusion

277. The term for the downward movement and accumulation of petroleum into a trap is:
(A) Generation
(B) Primary migration
(C) Secondary migration and accumulation
(D) Maturation

278. The primary use of barite in the petroleum industry is due to its:
(A) High hardness
(B) Low reactivity
(C) High specific gravity
(D) Color

279. Which of the following geological settings is LEAST likely to host a significant mineral deposit?
(A) An ancient subduction zone with associated magmatism.
(B) A large, stable craton with deep weathering profiles.
(C) A young, rapidly subsiding basin filled with uniform, uncemented sand.
(D) A rift valley with associated volcanism and faulting.

280. The National Aluminium Company (NALCO) operates a major bauxite mine at:
(A) Khetri, Rajasthan
(B) Sukinda, Odisha
(C) Panchpatmali, Odisha
(D) Malanjkhand, Madhya Pradesh

281. The heat source for the formation of many hydrothermal ore deposits is typically:
(A) The sun
(B) Radioactive decay in the crust
(C) A cooling igneous intrusion
(D) Frictional heat from faulting

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282. Which of the following correctly lists coal varieties in DECREASING order of rank?
(A) Anthracite, Bituminous, Lignite, Peat
(B) Lignite, Bituminous, Anthracite, Peat
(C) Peat, Lignite, Bituminous, Anthracite
(D) Bituminous, Anthracite, Peat, Lignite

(B) A placer deposit.
(C) A magmatic segregation deposit.
(D) A residual deposit.

200. Which of the following is NOT a significant use of Zinc?
(A) Making alloys like brass.
(B) Manufacturing die-castings.
(C) As a filament in incandescent light bulbs.
(D) Galvanizing iron and steel to prevent rust.

201. The East Coast Bauxite deposits of India, located in Odisha and Andhra Pradesh, are associated with which geological process?
(A) Hydrothermal activity
(B) Marine sedimentation
(C) Lateritization of khondalites and charnockites
(D) Volcanic eruption

202. Consider the following statements regarding the classification of mineral deposits:
1. Magmatic deposits form directly from magma.
2. Hydrothermal deposits are precipitated from hot aqueous solutions.
3. Sedimentary deposits are formed by processes operating at or near the Earth's surface.

Which of the above statements is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 only
(D) 1, 2, and 3

203. The term supergene" refers to mineralization processes that are:
(A) Related to igneous activity.
(B) Caused by ascending fluids from deep within the Earth.
(C) Caused by descending surface waters, typically involving weathering.
(D) Formed under high-grade metamorphic conditions.

204. Which of the following metals is primarily extracted from the ore mineral sphalerite?
(A) Zinc
(B) Lead
(C) Tin
(D) Copper

205. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : The 'rank' of coal is a measure of its degree of metamorphism or coalification.
Reason (R) : As rank increases, the proportion of fixed carbon increases, while moisture and volatile matter decrease.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

206. The Ratnagiri district of Maharashtra is known for its coastal deposits of:
(A) Bauxite and Ilmenite
(B) Gold
(C) Coal
(D) Copper

207. What is the fundamental requirement for the formation of an evaporite deposit?
(A) A high rate of sedimentation in a deep marine basin.
(B) A restricted basin in an arid climate where evaporation exceeds inflow.
(C) Intense volcanic activity along a mid-ocean ridge.
(D) Rapid erosion of a mountain range.

208. Match the non-metallic mineral with its key identifying property or association.
List I: (Mineral)
P. Asbestos
Q. Barite
R. Graphite
S. Gypsum
List II: (Property/Association)
1. Very soft (H=2), often forms in evaporite sequences
2. Fibrous habit, associated with serpentinites
3. Very soft (H=1-2), greasy feel, marks paper
4. Unusually high specific gravity for a non-metallic mineral
(A) P-1, Q-3, R-2, S-4
(B) P-2, Q-4, R-3, S-1
(C) P-2, Q-1, R-4, S-3
(D) P-3, Q-4, R-1, S-2

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(D) Gypsum

292. Given below are two statements regarding petroleum traps.
Statement I : A structural trap is formed by deformation of the reservoir rock, such as folding or faulting.
Statement II : A stratigraphic trap is formed by changes in rock type or lithology, such as a pinch-out or an unconformity.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

293. The Hazaribagh region in Jharkhand is famous for its deposits of:
(A) Gold
(B) Petroleum
(C) Mica and Coal
(D) Diamond

294. The mineral scheelite, an ore of tungsten, is often prospected for using what property?
(A) Its high magnetism
(B) Its strong radioactivity
(C) Its bright blue-white fluorescence under ultraviolet light
(D) Its very low density

295. Which of these is a process of magmatic concentration?
(A) Hydrothermal vein formation
(B) Evaporation in a lagoon
(C) Gravity settling of early-formed heavy crystals
(D) Weathering and leaching

296. The Digboi field in Assam produces oil from which geological formation?
(A) Gondwana Supergroup
(B) Deccan Traps
(C) Tipam Sandstones (Tertiary)
(D) Cuddapah Supergroup

297. The term 'ore genesis' refers to:
(A) The economic evaluation of a mineral deposit.
(B) The way in which mineral deposits are formed.
(C) The process of mining and extraction.
(D) The legal framework for mineral rights.

298. Identify the incorrect statement about coal.
(A) Coal is a combustible sedimentary rock.
(B) Vitrinite, liptinite, and inertinite are the main maceral groups.
(C) The formation of coal from peat is called diagenesis and coalification.
(D) All varieties of coal have the same carbon content and calorific value.

299. The Kakrapar Atomic Power Station is located in which Indian state?
(A) Tamil Nadu
(B) Gujarat
(C) Karnataka
(D) Rajasthan

300. Arrange the following in the order they would be encountered from the surface downwards in a typical weathered sulphide deposit.
1. Primary ore (Hypogene zone)
2. Gossan (Leached cap)
3. Enriched sulphide zone (Supergene zone)

Which of the following represents the correct sequence?
(A) 1, 2, 3
(B) 2, 3, 1
(C) 3, 2, 1
(D) 2, 1, 3

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crust meet cold seawater. They are significant global sources of base metals and often occur in distinct geological sequences of volcanic rocks.

36. (B) Later formation of the interstitial mineral
An ore texture where one mineral fills the spaces or interstices between pre-existing crystals of another mineral indicates that the interstitial mineral formed at a later stage. This relationship reveals the relative timing of mineral deposition within the ore body. Such textures are essential for geologists to reconstruct the paragenetic sequence and understand the chronological evolution of the mineralization event.

37. (C) A pinch-out or unconformity trap
Stratigraphic traps are formed by changes in rock type or geological unconformities rather than by structural deformation like folding or faulting. Examples include pinch-outs, where a reservoir layer thins and disappears between impermeable beds, or unconformities where tilted reservoir rocks are capped by younger, non-porous layers. In contrast, anticlines and salt domes are examples of structural traps formed by rock movement.

38. (C) Chromite
The Sukinda valley in Odisha is world-renowned for hosting some of the largest and highest-grade chromite deposits. These deposits are associated with ultramafic rocks and are critical for India's stainless steel industry. The region accounts for a vast majority of the country's chromite production, making it a strategically important mining district for both domestic consumption and international trade.

39. (C) Statement I is true, but Statement II is false.
Muscovite and phlogopite are accurately described in the first statement as potassium-rich and magnesium-rich micas, respectively. However, the second statement is false because mica is primarily used as an electrical and thermal insulator due to its high dielectric strength and heat resistance, rather than as a refractory brick. Refractory bricks are typically made from minerals like magnesite or chromite.

40. (D) High-grade iron ore
The Bailadila range in Chhattisgarh is famous for its massive deposits of exceptionally high-grade iron ore. The ore is primarily hematite and is known for its high iron content and purity. Much of this ore is used in domestic steel plants and exported globally. The region is a vital hub for the Indian mining industry and contributes significantly to the economy.

41. (C) Maceral associations forming bands with a minimum width of 50 micrometers.
Microlithotypes are microscopic associations of different macerals that form distinct bands within coal. By convention, these bands must have a minimum width of 50 micrometers to be classified as a microlithotype. Studying these associations provides detailed information about the original depositional environment and the plant communities that contributed to the coal's formation, which influences its industrial properties.

42. (D) Barite
Chrysotile, amosite, and crocidolite are all varieties of asbestos, a group of naturally occurring fibrous silicate minerals known for their heat resistance and strength. Barite, however, is a barium sulphate mineral that is not fibrous and is primarily used as a weighting agent in drilling muds. It belongs to a completely different chemical and structural group than the asbestos minerals.

43. (A) 3, 2, 1, 4
The rank of coal increases as it matures from peat to lignite, then to bituminous, and finally to anthracite. This progression reflects the gradual increase in carbon content and energy potential due to heat and pressure over geological time. Peat is the least mature form, while anthracite represents the highest rank with the highest carbon percentage and calorific value.

44. (B) Intense chemical weathering and leaching of soluble materials.
Residual deposits like bauxite and lateritic iron ore form through intense chemical weathering in humid tropical environments. High rainfall leaches away soluble elements like silica, calcium, and magnesium, leaving behind a concentrated residuum of insoluble oxides. This in-situ enrichment process creates valuable ore bodies from parent rocks that originally contained

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rocks. Sublimation, contact metasomatism, and volcanogenetic processes are accurately described as common mineral deposit formation mechanisms.

9. (A) Both A and R are true and R is the correct explanation of A.
Magmatic concentration occurs when early-formed, heavy crystals like chromite or nickel sulphides sink through the magma and accumulate at the base of the chamber due to gravity. This physical segregation creates concentrated ore layers. The assertion correctly identifies the result of this process, and the reason explains the physical mechanism of crystal settling that leads to such valuable accumulations.

10. (A) The spatial distribution of minerals in a systematic pattern.
Zoning refers to the systematic spatial arrangement of minerals within a deposit or across a mining district. This pattern often develops in response to gradients in temperature, pressure, or chemical concentration of the ore-forming fluids. For example, hydrothermal veins may show a progression from high-temperature minerals near the source to lower-temperature minerals further away in a systematic fashion.

11. (D) A concentration of heavy and resistant minerals in sediments, formed by mechanical action.
Placer deposits are formed by the mechanical concentration of heavy, durable, and chemically resistant minerals. Flowing water in rivers or waves on beaches sorts these minerals from lighter sediment based on their high specific gravity. Common minerals found in these deposits include gold, tin, and diamonds, which accumulate in specific areas like stream bends or beach fronts.

12. (A) P-4, Q-2, R-1, S-3
Banded iron formations are classic sedimentary deposits. Residual concentration involves weathering that leaves insoluble ores like bauxite behind. Evaporation leads to the formation of salt and gypsum beds in restricted basins. Supergene enrichment occurs when metals leach from upper zones and re-precipitate below the water table, creating richer secondary zones for minerals like copper or silver.

13. (C) Replacement texture: Presence of pseudomorphs where one mineral replaces another.
Replacement texture occurs when a new mineral replaces a pre-existing one, often preserving the original shape or structure. This process results in pseudomorphs, which provide evidence of changing chemical conditions within the deposit. Other textures like colloform involve concentric banding, while graphic textures show intergrowths. Understanding these relationships is vital for interpreting the sequence of mineralization during geological history.

14. (A) The Cause and Effect are both correct, and the Cause is the direct reason for the Effect.
Bauxite deposits form through intense chemical weathering in tropical environments where high rainfall and temperature leach silica and other soluble components from aluminous parent rocks. This process leaves behind a residuum rich in aluminum oxides. The cause accurately describes the lateritization process, and the effect correctly identifies bauxite as the resulting valuable ore deposit formed through concentration.

15. (A) Bauxite: Recent volcanic ash deposits
Bauxite is a residual deposit formed through the intense weathering of aluminous rocks like granite or basalt in tropical climates, not primarily from recent volcanic ash. In contrast, chromite is correctly associated with ultramafic rocks, tin with granitic pegmatites, and manganese nodules with the deep-sea floor. The misidentification highlights the specific environmental conditions required for bauxite formation.

16. (B) 2 and 3 only
Ore microscopy primarily involves studying opaque minerals using reflected light, not transmitted light, which is used for silicate minerals. Features like exsolution lamellae provide vital clues about the cooling history and thermal conditions during formation. Reflectivity and color are essential diagnostic properties used to identify different ore minerals under reflected light, making the second and third statements correct.

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tropical and subtropical regions. Intense chemical weathering leaches away soluble components from aluminous parent rocks, leaving behind a concentrated layer of aluminum oxides and hydroxides. This process requires high rainfall and temperature to facilitate the removal of silica and other elements, making bauxite the primary global ore for aluminum production.

72. (D) Spores, cuticles, and resins
The liptinite maceral group in coal is derived from the waxy and resinous parts of ancient plants, such as spores, pollen, cuticles, and resins. These components are more resistant to decay and chemical alteration compared to woody tissues. Liptinite typically has a higher hydrogen content than other maceral groups, which influences the coal's behavior during heating and its suitability for producing liquid fuels.

73. (A) 2, 3, 1, 4
The formation of a petroleum deposit begins with the generation of hydrocarbons from organic-rich source rocks. These fluids then migrate through permeable carrier beds until they accumulate in a geological trap. Finally, they must be preserved under an impermeable seal rock to prevent escape. This sequential process is fundamental to the development of all economically extractable oil and gas accumulations.

74. (C) Titanium
Ilmenite and rutile are the primary ore minerals for titanium and are found in significant concentrations in the beach sands of Kerala. These heavy minerals are naturally sorted by wave action to form placer deposits. Titanium extracted from these ores is valued for its high strength-to-weight ratio and corrosion resistance, making it essential for aerospace, medical implants, and high-performance industrial equipment.

75. (C) Hydrothermal zoning
Hydrothermal zoning describes the systematic spatial distribution of minerals around a central source, such as an igneous intrusion. This pattern develops because different minerals precipitate at different temperatures and chemical conditions as the hydrothermal fluids move away from the heat source and cool. A typical sequence might show copper near the center, followed by lead and then zinc in outer zones.

76. (B) Gypsum
Gypsum is an essential mineral in the cement industry, where it is added to the final product to control the setting time of the cement. It prevents the cement from hardening too rapidly when mixed with water, allowing for proper application and shaping. This non-metallic mineral is typically sourced from evaporite deposits and is critical for ensuring the quality of construction materials.

77. (C) Statement I is true, but Statement II is false.
The Mineral Concession Rules in India provide the formal legal framework for obtaining prospecting licenses and mining leases, as stated in the first sentence. However, the second statement is false because these rules are specifically designed to ensure that mineral resources are explored and exploited in a scientific, systematic, and regulated manner, rather than an unscientific or haphazard way.

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78. (B) Rarity, beauty, and market demand
The distinction between precious and semi-precious minerals is primarily based on subjective factors such as rarity, beauty, and current market demand rather than specific geological properties. Precious minerals, like diamonds and rubies, are exceptionally rare and highly valued. Semi-precious minerals, such as amethyst or garnet, may be beautiful and durable but are more common and generally have lower market prices than precious stones.

79. (A) The depth and temperature range for oil generation from kerogen.
The term 'oil window' refers to the specific range of temperatures and depths within a sedimentary basin where kerogen is thermally converted into liquid crude oil. This typically occurs between sixty and one hundred and twenty degrees Celsius. If temperatures are too low, the organic matter remains immature; if too high, the oil is cracked into natural gas or destroyed.

80. (C) High-grade coals form under higher temperatures than low-grade coals.
High-grade coals, such as anthracite, form under conditions of higher temperature and pressure compared to low-grade varieties like lignite. This process, known as coalification, increases the carbon content and energy density of the organic

specific chemical or physical properties rather than their rarity or gem-like beauty.

27. (D) 1, 2, and 3
Rock phosphate provides essential phosphorus, potash provides potassium, and gypsum serves as a source of sulfur and a soil conditioner. All three minerals are fundamental raw materials for the fertilizer industry to enhance soil fertility and crop yields. Their combined use ensures that plants receive the necessary nutrients for growth, making them critical components of global agricultural production.

28. (B) Critical minerals
Critical minerals are those essential for a nation's economy and security but whose supply is at risk due to limited domestic availability or geopolitical factors. These minerals must often be imported to sustain key industrial and technological sectors. Identifying and securing these resources is a major focus of national mineral policies to ensure economic resilience and support high-tech manufacturing industries.

29. (C) It encourages scientific mining and sustainable mineral development.
The National Mineral Policy of India aims to modernize the mining sector by promoting scientific methods, enhancing exploration, and ensuring sustainable development. It encourages private sector participation and emphasizes environmental protection alongside economic growth. The policy seeks to balance the need for mineral resources with social responsibility and conservation, rather than restricting all activities or solely focusing on raw exports.

30. (A) Both A and R are true and R is the correct explanation of A.
Geological structures like anticlines, fault traps, and salt domes are essential for petroleum accumulation. These configurations provide a sealed environment that prevents the upward migration of hydrocarbons from the reservoir rock. The assertion correctly identifies these traps, and the reason explains how their physical arrangement halts oil and gas movement, allowing for the formation of large, extractable underground deposits.

31. (A) Vitrinite
Vitrinite is the most common maceral group in coal, primarily derived from the woody tissues of ancient plants. It is a major component of bright coal and is characterized by its glassy appearance under a microscope. This maceral plays a significant role in determining coal rank and quality, as it reacts predictably to heat during the coalification process.

32. (D) Compaction of terrestrial plant matter in swampy environments.
Most coal deposits originate from the accumulation and burial of terrestrial plant matter in low-oxygen, swampy environments. Over geological time, heat and pressure transform this organic debris into peat and eventually into various ranks of coal. This process, known as coalification, occurs within continental or deltaic sedimentary basins rather than in deep marine or igneous geological settings.

33. (B) P-4, Q-1, R-3, S-2
Graphite is widely used as a lubricant and pencil lead due to its layered structure. Gypsum is essential for cement and plasterboard manufacturing. Barite serves as a weighting agent in drilling mud because of its high density. Mica is valued as an electrical insulator and in pigments. Matching these minerals to their specific industrial uses highlights their economic importance.

34. (C) Migration
Migration refers to the movement of hydrocarbons from the organic-rich source rock where they were generated into porous and permeable reservoir rocks. This process is driven by buoyancy and pressure gradients within the sedimentary basin. Migration can be primary, out of the source rock, or secondary, through carrier beds until the oil and gas are trapped by geological structures.

35. (B) Massive sulphide lenses formed on the seafloor during submarine volcanism.
Volcano genetic massive sulphide deposits are formed on the seafloor through submarine volcanic activity and associated hydrothermal venting. They consist of lenses of metal sulphides, primarily copper, lead, and zinc. These deposits precipitate when hot, metal-rich fluids from the

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molybdenite is an ore of molybdenum, cassiterite remains the global standard for tin extraction due to its high tin content and relative abundance.

54. (A) P-3, Q-4, R-1, S-2
The Malanjkhand belt is a major copper source, while Panchpatmali is a primary bauxite deposit. Hutti is one of India's leading gold mines, and Zawar is famous for lead and zinc production. Correctly matching these ores to their major producing areas reflects the geographical distribution of India's mineral wealth and the importance of these specific regions to the national mining industry.

55. (B) The legal right granted by the government to prospect or mine.
A mineral concession is a legal agreement or permit granted by the government that allows an individual or company to explore for or extract minerals from a specific area. This includes prospecting licenses and mining leases. These concessions are regulated by national laws to ensure that mineral resources are developed systematically, safely, and in accordance with environmental and economic policies.

56. (B) Macerals
Macerals are the microscopic organic constituents that make up coal, derived from various parts of ancient plants. They are grouped into three main categories: vitrinite, liptinite, and inertinite. Analogous to minerals in inorganic rocks, macerals determine the chemical and physical properties of coal. Their study under a microscope is essential for assessing coal rank, quality, and potential industrial applications during processing.

57. (C) Tamil Nadu
Tamil Nadu is the largest producer of lignite coal in India, with major deposits centered in the Neyveli region. Lignite is a lower-rank coal characterized by high moisture content. It is extensively used for thermal power generation in the state. The Neyveli Lignite Corporation manages these large-scale open-cast mines, which are crucial for meeting the energy demands of southern India.

58. (C) Statement I is true, but Statement II is false.
Bombay High is indeed India's most significant offshore petroleum-producing field, as stated in the first sentence. However, the second statement is false because the primary productive horizons in this field are found within limestone reservoirs of the Miocene age, not in Jurassic sandstones. This geological distinction is essential for understanding the specific reservoir characteristics and petroleum systems of the Mumbai offshore region.

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59. (B) Tungsten
Wolframite is a primary ore mineral for tungsten, consisting of an iron-manganese tungstate. It is typically found in high-temperature hydrothermal veins and pegmatites associated with granitic rocks. Tungsten extracted from wolframite is valued for its extremely high melting point and hardness, making it essential for manufacturing cutting tools, filaments, and specialized alloys used in aerospace and defense industries.

60. (C) Magnetic surveys
Prospecting for atomic minerals like uranium and thorium utilizes methods that detect radiation, such as scintillometer surveys and radon gas emanometry. Geochemical soil sampling is also used to identify traces of radioactive elements. Magnetic surveys, while useful for mapping structural features or certain metallic ores, are not a primary or direct method for detecting the radioactivity associated with atomic mineral deposits.

61. (D) Uranium
The Jaduguda mines in the Singhbhum district of Jharkhand are India's first and most famous uranium mines. They have been a primary source of uranium for the country's nuclear power and research programs for decades. The ore is processed locally to produce uranium concentrates. These mines represent a critical asset for India's strategic energy security and the development of its nuclear industry.

62. (C) Methane
Methane is the primary and most abundant constituent of natural gas, typically making up over ninety percent of its composition. While it may contain smaller amounts of other

much lower concentrations of aluminum or iron minerals.

45. (B) Lead and Zinc
The Zawar mines in Rajasthan are historically and geologically significant for being one of the oldest and largest sources of lead and zinc in India. Mining in this region dates back centuries, providing essential metals for various ancient and modern applications. The deposits occur in carbonate rocks and are managed with modern technologies to meet the country's industrial demands.

46. (B) Promoting sustainable development balancing economic growth and environmental protection.
The National Mineral Policy emphasizes sustainable development, seeking to balance the extraction of mineral resources with environmental conservation and social responsibility. It encourages modern, scientific mining practices and efficient resource utilization. The policy aims to ensure that mining contributes to long-term economic growth without compromising the environment, rather than focusing solely on immediate revenue or prohibiting all mineral exports.

47. (D) 1, 2, and 3
Asbestos is commonly found in serpentinized ultramafic rocks. Gypsum is an evaporite mineral that precipitates from saline water in restricted basins. Graphite occurs in high-grade metamorphic rocks where organic matter has been converted into crystalline carbon. All three statements correctly describe the typical geological associations and origins of these important non-metallic minerals found in various crustal environments.

48. (B) A strategic mineral
A strategic mineral is one essential for a nation's defense and industrial sectors but whose supply depends on imports from other countries. Because these minerals are critical for military technology and national security, ensuring a stable supply is a major priority for government policy. This classification differs from abundant or semi-precious minerals, as it focuses specifically on necessity and supply vulnerability.

49. (C) As a weighting agent in drilling muds for the oil and gas industry
Barite is primarily used as a weighting agent in the drilling muds required for oil and gas exploration. Its unusually high specific gravity for a non-metallic mineral helps prevent high-pressure fluids from erupting during the drilling process. While it has minor uses in paints and chemicals, its role in the energy sector is its most significant economic application globally.

50. (B) Maharashtra
The Tarapur Atomic Power Station is located in the Palghar district of Maharashtra. Inaugurated in 1969, it was India's first commercial nuclear power facility. The station plays a critical role in providing electrical energy to the western grid. Its development marked the beginning of India's nuclear energy program, utilizing boiling water reactors and later adding pressurized heavy water reactors for power generation.

51. (A) Both A and R are true and R is the correct explanation of A.
The process of supergene enrichment can significantly upgrade low-grade primary sulphide deposits into economically viable ones. Surface weathering leaches metals like copper from the upper oxidized zone and re-precipitates them in a concentrated zone at or below the water table. The assertion identifies the economic impact, while the reason correctly explains the chemical and physical mechanisms of leaching and re-deposition.

52. (D) An iron-rich, porous, and weathered cap over a sulphide ore body.
A gossan is an iron-rich, porous rock cap that forms at the surface through the weathering and oxidation of a subsurface sulphide ore body. It is often reddish-brown due to the presence of limonite and hematite. Geologists use gossans as valuable indicators for locating buried ore deposits, as they represent the insoluble remains of primary minerals that have been leached.

53. (C) Cassiterite
Cassiterite is the primary and most important ore mineral for tin. It is a heavy, durable oxide mineral typically found in granitic pegmatites, hydrothermal veins, and placer deposits. While wolframite and scheelite are ores of tungsten and

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17. (D) Statement I is false, but Statement II is true.
Supergene sulphide enrichment is a near-surface weathering process, not a deep-crustal high-pressure event. It involves the oxidation of primary sulphide minerals near the surface and the subsequent re-precipitation of metals at or below the water table. This creates a secondary zone of richer ore. The first statement incorrectly describes the depth, while the second accurately explains the chemical mechanism.

18. (A) Hematite
Hematite is the primary iron ore mineral, distinguished by its characteristic reddish-brown streak. This property remains consistent regardless of the mineral's outward appearance, which can range from metallic gray to dull red. As a major source of iron globally, hematite is found in vast sedimentary formations and is vital for the steel industry and various industrial applications worldwide.

19. (A) 1, 2, 4, 3
A typical weathered sulphide deposit displays a vertical sequence starting with the gossan at the surface, which is a leached cap. Below this lies the zone of oxidized enrichment, followed by the zone of supergene sulphide enrichment at or near the water table. The sequence concludes with the primary or hypogene sulphide zone, which remains unaffected by surface weathering.

20. (D) Rajasthan
The Khetri copper belt is a prominent mineralized zone situated in the state of Rajasthan. It is one of the oldest and most significant copper mining regions in India. The mineralization is primarily hosted in metamorphic rocks of the Delhi Supergroup. Extensive mining and smelting facilities are established here to extract and process copper for domestic industrial needs and exports.

21. (C) As a primary source of aluminum metal.
Manganese is primarily used as an alloying element in steel production to increase toughness and strength. It also serves as a vital component in dry-cell batteries and as an oxidizing agent in chemical industries. However, manganese is never used as a source of aluminum metal, as aluminum is exclusively extracted from bauxite ore through the electrolytic smelting process.

22. (B) Lithotypes
Lithotypes are the macroscopic ingredients of coal that are visible to the naked eye within a coal seam. These include varieties like vitrain, clarain, durain, and fusain, each possessing distinct physical properties and appearances. While macerals are the microscopic organic constituents, lithotypes refer to the banded layers and textures observed in natural coal samples during field or hand specimen examination.

23. (D) Percentage of carbon and calorific value.
Coal rank indicates the degree of coalification or maturity reached by organic matter through heat and pressure over time. It is primarily measured by the percentage of fixed carbon and the calorific value. Higher rank coals, such as anthracite, possess greater carbon content and energy potential compared to lower rank varieties like peat and lignite, which contain more moisture.

24. (C) Statement I is true, but Statement II is false.
Petroleum forms from the thermal maturation of organic matter, primarily marine plankton, buried deep within sedimentary basins under high pressure and temperature. The first statement accurately describes this origin. The second statement is false because the transformation into hydrocarbons requires the significant heat and pressure found at depth, rather than the atmospheric conditions present at the Earth's surface.

25. (C) Contact Metasomatism
Contact metasomatism occurs when heat and chemically active fluids from a cooling magma body react with the surrounding country rock. This process leads to the formation of new minerals and changes in the rock's composition, often creating valuable ore deposits like skarns. This differs from simple thermal metamorphism as it involves the significant addition of material from the magmatic source.

26. (A) Diamond
Diamond is classified as a precious mineral due to its extreme hardness, rarity, and exceptional aesthetic qualities after cutting. It has significant value in both jewelry and industrial applications. In contrast, minerals like gypsum, barite, and graphite are considered industrial or non-metallic minerals, which are valued for their

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hydrocarbons like ethane, propane, and butane, as well as non-hydrocarbon gases, methane provides the main energy content. It is valued as a clean-burning fuel for heating, electricity generation, and various industrial chemical processes.

63. (C) Gypsum - Oxide
Gypsum is a calcium sulphate mineral, not an oxide. It forms through the evaporation of seawater in restricted basins. Barite is correctly classified as a sulphate, graphite as a native element, and ochre as an iron oxide or hydroxide. Identifying the correct chemical group is fundamental in mineralogy and helps determine a mineral's origin, properties, and potential industrial uses.

64. (D) As a natural pigment in paints
Ochre is a natural earth pigment consisting of a mixture of clay and iron oxides or hydroxides, such as hematite or limonite. It has been used for thousands of years as a coloring agent in paints and coatings. Due to its stability and non-toxic nature, ochre remains a valued material in the manufacturing of traditional and industrial pigments for various surfaces.

65. (D) 1, 2, and 3
Coal rank increases with maturity, requiring heat, pressure, and time. Oil traps are essential to contain accumulated hydrocarbons. Natural gas found in coal seams is known as coalbed methane. All three statements accurately describe the fundamental geological and physical characteristics of fuel minerals, including their formation, preservation, and common associations within sedimentary basins found throughout the Earth's crust.

66. (D) The integration of source, reservoir, trap, and proper timing.
A commercial petroleum accumulation requires the successful integration of four key elements: a source rock to generate hydrocarbons, a reservoir rock to store them, a trap to contain them, and proper timing of migration into the trap. If any of these factors is absent or poorly timed, an economically viable deposit will not form, regardless of the individual quality of the rocks.

67. (D) Karnataka
The Kolar Gold Fields are located in the state of Karnataka. This region was once one of the deepest and most productive gold mining centers in the world, with history stretching back over a century. Although large-scale mining operations have largely ceased, the area remains a significant geological landmark and a testament to India's historical and economic contributions to global gold production.

68. (A) Sublimation
Sublimation is the geological process where minerals are deposited directly from a volcanic gas or vapor without passing through a liquid phase. This often occurs around volcanic vents and fumaroles where rapid cooling causes gaseous sulfur or other volatile compounds to crystallize into solids. While not a primary source for large-scale mining, sublimation produces distinctive mineral occurrences in active volcanic regions.

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69. (C) The spatial and geometric relationship of minerals within the ore.
Ore texture refers to the microscopic and macroscopic spatial and geometric relationships between the individual mineral grains within an ore body. It includes the size, shape, and intergrowth patterns of both ore and gangue minerals. Studying these textures is critical for understanding the sequence of mineral formation and for designing effective methods for mineral processing and metallurgical extraction during mining operations.

70. (A) Both A and R are true and R is the correct explanation of A.
Pegmatites are economically vital because they host exceptionally large crystals of valuable minerals like beryl and mica. They form from the final, volatile-rich fractions of cooling granitic magma. The presence of water and other volatiles lowers the viscosity and facilitates rapid crystal growth. The assertion highlights their economic importance, and the reason accurately explains the magmatic process that allows these minerals to form.

71. (C) Residual concentration (lateritization)
Bauxite forms through the process of residual concentration, specifically lateritization, in

ANSWERS

1. (B) Magmatic concentration
Magmatic concentration is the process where ore minerals crystallize directly from cooling magma. This occurs through various mechanisms like liquid immersion, fractional crystallization, or gravity settling. Early-formed crystals of minerals like chromite or magnetite settle at the base of the chamber, creating concentrated layers. This differs from hydrothermal or sedimentary processes that involve aqueous fluids or surface deposition.

2. (A) The sequence or order in which minerals are formed in a deposit.
Paragenesis defines the chronological order of mineral deposition within a specific ore body. It represents the sequential history of crystallization, providing insights into the evolving chemical and physical conditions during the deposit's formation. This sequence is typically determined through detailed microscopic examination of mineral textures, intergrowths, and cross-cutting relationships within the identified mineral assemblage found in rocks.

3. (C) They refer to minerals or mineral assemblages that indicate the temperature of formation.
Geological thermometers are minerals or mineral assemblages that serve as indicators of the temperatures during rock or ore formation. These indicators include specific mineral stability ranges, phase changes, or the presence of fluid inclusions. By studying these geological features, scientists can reconstruct the thermal history of a deposit, which is essential for understanding the overall mineralization process during development.

4. (C) Statement I is true, but Statement II is false.
Carbonatites are rare igneous rocks containing more than fifty percent carbonate minerals, often associated with rift-related alkaline complexes. They are significant economic sources of rare earth elements, niobium, and phosphate. The second statement is incorrect because carbonatites are igneous in origin, not sedimentary, and they frequently host highly valuable mineral deposits rather than being devoid of economic worth.

5. (C) An exceptionally coarse-grained igneous rock containing rare minerals.
Pegmatites are exceptionally coarse-grained igneous rocks that form during the final stages of magma crystallization. They are characterized by crystals that can reach several meters in size. These rocks often contain rare minerals and elements like beryl, tourmaline, and lithium-bearing species. Their formation involves water-rich residual fluids that facilitate rapid crystal growth and concentrate rare elements during cooling.

6. (B) Hydrothermal deposition
Hydrothermal deposition involves the precipitation of minerals from hot, aqueous solutions circulating through fractures and veins in the Earth's crust. These solutions often originate from cooling igneous bodies but can travel significant distances before depositing their mineral load. This process accounts for a vast array of metallic deposits, including gold, silver, and lead, found far from parent intrusions.

7. (D) The distance of the deposit from the Earth's core.
Ore localization is controlled by structural, lithological, and magmatic factors. Faults and folds create pathways for mineralizing fluids, while permeable rock layers provide space for deposition. Proximity to igneous intrusions often determines the heat and fluid source. However, the specific distance from the Earth's core is not a practical or recognized control for the localization of mineral deposits.

8. (A) Pegmatites are formed through the rapid cooling of low-viscosity lava on the surface.
Pegmatites are coarse-grained igneous rocks formed from volatile-rich residual fluids deep within the crust, allowing for the growth of massive crystals. They are not formed by the rapid cooling of low-viscosity lava on the surface, which typically produces fine-grained volcanic

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matter. While most coal is terrestrial in origin and not marine, the maturity of any deposit is primarily determined by its thermal and pressure history over time.

81. (C) Magnesite and Iron Ore
The Salem district in Tamil Nadu is famous for its significant deposits of magnesite and iron ore. Magnesite is a vital refractory material used in the steel industry, while the iron ore in the region has been a source for local metallurgical activities. These mineral resources contribute significantly to the industrial development and economic activity of the state and the nation.

82. (C) Bireflectance (or reflection pleochroism)
Bireflectance is the optical property of certain anisotropic ore minerals to change color or shade when the microscope stage is rotated under plane-polarized reflected light. This diagnostic feature is essential for identifying minerals in ore microscopy. It is the reflected light equivalent of pleochroism seen in transmitted light and varies depending on the mineral's crystalline structure and its orientation during the examination.

83. (A) P-3, Q-1, R-4, S-2
Kaiga is located in Karnataka, while Kakrapar is in Gujarat. Rawatbhata is a major facility in Rajasthan, and Kudankulam is the largest nuclear power station in Tamil Nadu. Correctly identifying the locations of these atomic power stations is important for understanding India's nuclear energy infrastructure and the geographical distribution of its primary power generation facilities across various states.

84. (C) Their high specific gravity and resistance to weathering.
The formation of placer deposits for gold and tin relies on their exceptionally high specific gravity and chemical resistance. These properties allow the minerals to withstand weathering and be mechanically sorted by flowing water. While lighter minerals are washed away, these heavy, durable grains accumulate in areas of reduced current velocity, such as riverbeds or beaches, creating economically viable concentrations.

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85. (D) Accumulation of heavy minerals by gravity at the base of a magma chamber.
Hydrothermal deposits are formed from hot aqueous solutions circulating through the crust, often resulting in veins or disseminations associated with quartz and calcite. Gravity settling of heavy minerals at the base of a magma chamber describes magmatic segregation, which is a completely different process. Magmatic segregation occurs within the magma itself, while hydrothermal activity involves separate, water-rich mineralizing fluids.

86. (C) Pyrites (for sulphuric acid)
The Amjhore deposits in Bihar are well-known for hosting large amounts of pyrite. While pyrite itself is an iron sulphide, its primary industrial value in this region is as a source of sulfur for manufacturing sulphuric acid. This acid is a critical component in the production of phosphate fertilizers, making these deposits an important resource for India's domestic agricultural chemical industry.

87. (D) 1, 2, and 3
Ore deposition is influenced by structural pathways like faults, chemical reactions between fluids and host rocks, and physical changes in temperature and pressure. All three factors play essential roles in determining where and how minerals precipitate. Together, these controls explain the localization of ore bodies within the Earth's crust, providing a framework for geologists to understand and predict mineral occurrences.

88. (C) Vitrinite
Vitrinite is the most abundant and characteristic maceral group in most coals, responsible for its bright, glassy appearance and coherent nature. It is derived from the woody tissues of plants and is highly sensitive to heat, making it a reliable indicator of coal rank. Due to its prevalence and predictable properties, vitrinite is a key focus in coal petrology and industrial quality assessment.

89. (C) Evaporation deposit
Rock salt, or halite, is a classic example of an evaporite deposit. It forms when saline water in restricted basins evaporates, causing the dissolved minerals to reach supersaturation and precipitate as solid layers. These deposits typically occur in

142. (C) As a fireproofing and insulating material
Asbestos is a group of fibrous minerals valued for its exceptional heat resistance, high tensile strength, and chemical durability. Historically, these properties made it a primary material for fireproofing and thermal insulation in buildings, ships, and industrial equipment. While its use has been restricted due to health concerns, its unique physical characteristics were the foundation for its widespread application in various safety and construction industries.

143. (D) 1, 2, and 3
Cassiterite and wolframite are the primary ores of tin and tungsten, respectively, and are typically associated with granitic igneous environments. Both minerals are heavy and chemically resistant, which allows them to survive weathering and accumulate in economically valuable placer deposits. All three statements correctly describe the mineralogy, geological associations, and physical behaviors of these two closely related and industrially important metallic minerals.

144. (B) Economically worthless minerals associated with the ore minerals.
Gangue refers to the commercially worthless minerals that are found interspersed with valuable ore minerals in a deposit. Common examples include quartz, calcite, and various silicate minerals. During the mining and processing stages, gangue must be separated from the ore minerals to produce a marketable concentrate. The ratio of ore to gangue determines the overall grade and economic viability of a mineral deposit.

145. (A) Both A and R are true and R is the correct explanation of A.
The National Mineral Policy of India emphasizes value addition and mineral processing to maximize the economic benefits derived from the country's mineral wealth. The assertion identifies this policy focus, and the reason correctly explains that exporting finished or semi-finished products generates significantly more revenue and employment than exporting raw ores. This strategy aims to strengthen the domestic manufacturing sector and enhance national income.

146. (A) In the manufacturing of stainless steel and other alloys.
Nickel's most significant industrial use is as an alloying element, particularly in the production of stainless steel. It imparts essential properties like corrosion resistance, strength, and toughness. Approximately two-thirds of global nickel production is dedicated to stainless steel manufacturing. It is also used in other specialized alloys and for plating. This versatile metal is critical for modern industrial, construction, and high-performance engineering applications.

147. (C) Reservoir rock
A reservoir rock is a geological formation characterized by sufficient porosity to store hydrocarbons and enough permeability to allow them to flow through it. Common examples include sandstones and certain types of limestone. This rock body serves as the underground container for petroleum and natural gas after they have migrated from the source rock, making it a critical component of any petroleum system.

148. (B) P-4, Q-3, R-1, S-2
Anisotropism is observed between crossed polarizers, while reflectivity measures the light reflected from a mineral's surface. Internal reflections occur within translucent minerals, and hardness is the resistance to scratching or polishing. Correctly matching these diagnostic properties is fundamental for mineral identification in ore microscopy. These physical and optical characteristics allow geologists to distinguish between different ore minerals and understand their relationships.

149. (C) Barites and Asbestos
The Cuddapah basin in Andhra Pradesh is geologically significant and known for its important deposits of barite and asbestos. The barite deposits in this region are among the largest in the world and are crucial for the global oil drilling industry. Asbestos, particularly the chrysotile variety, is also found associated with specific rock formations within the basin, contributing to the area's diverse mineral wealth.

150. (A) Magmatic concentration occurs in magma; metasomatism affects country rock.
Magmatic concentration involves the segregation of ore minerals directly from a cooling magma

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in energy history, and the region continues to be an important area for oil and gas production in India.

99. (B) Ore microscopy or Mineragraphy
Ore microscopy, also known as mineragraphy, is the specialized study of opaque ore minerals using a reflected light microscope. This technique allows geologists to identify minerals based on properties like reflectivity, color, and hardness. It also reveals important textures and intergrowth patterns that provide clues about the origin and history of the ore deposit, which is critical for effective mineral processing.

100. (B) They serve as a crucial raw material base for industrial development.
Minerals are of immense economic importance because they provide the essential raw materials required for nearly all sectors of industrial development, including infrastructure, energy production, and manufacturing. They are fundamental to technological progress and national security. A stable supply of mineral resources is a prerequisite for a modern industrial society and is a major driver of economic growth and global trade.

101. (C) Contact metasomatism
Contact metasomatism involves the chemical alteration of country rock by heat and volatile fluids released from a nearby cooling igneous intrusion. This process introduces new elements and often results in the formation of economically valuable minerals in the contact zone, such as in skarn deposits. It differs from simple contact metamorphism because it includes significant material exchange between the magma and host rocks.

102. (A) 1, 3, 2, 4
The formation of a placer deposit begins with the weathering and erosion of a primary mineral source. The eroded material is then transported by a river, which sorts the grains by weight. Heavy minerals accumulate in areas of lower energy, such as river bends, while lighter minerals continue to be carried further downstream. This sequence represents the mechanical concentration process of placers.

103. (C) Remnants of host rock texture preserved within the ore mineral.
A characteristic feature of ores formed by replacement is the preservation of original host rock textures or structures within the new mineral. This occurs when mineralizing fluids dissolve the original rock and simultaneously deposit new minerals in its place. These ghost textures" provide clear evidence that the ore did not fill open spaces but instead physically replaced the pre-existing rock material.

104. (D) 1, 2, and 3
Graphite is a soft, lubricating form of carbon found in metamorphic rocks. Barite is a remarkably high-density sulphate mineral used in drilling. Chrysotile is the most common asbestos variety, known for its fibrous habit and association with serpentinites. All three statements accurately describe the physical properties, chemical classifications, and typical geological occurrences of these important and versatile non-metallic mineral resources.

105. (C) Diamond
The Panna belt in Madhya Pradesh is India's most significant and historically famous region for the occurrence of diamonds. These gemstones are found in both primary kimberlite pipes and secondary alluvial gravels. The region has been a source of diamonds for centuries and continues to be a major area for gemstone exploration and mining, contributing to the country's luxury and industrial sectors.

106. (C) Visually distinct macroscopic bands and layers found within coal seams.
Lithotypes are the macroscopic bands and layers that can be seen with the naked eye in a coal seam. Examples include vitrain, clarain, durain, and fusain. These layers reflect the varying plant materials and depositional conditions present during the coal's formation. While macerals are studied microscopically, lithotypes provide important information about the overall physical appearance and banded nature of natural coal samples.

107. (A) Both A and R are true and R is the correct explanation of A.
Hydrothermal solutions are major agents in the formation of metallic ore deposits because hot,

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arid climates where evaporation exceeds the inflow of fresh water, resulting in thick beds of salt and other minerals like gypsum over time.

90. (A) Both A and R are true and R is the correct explanation of A.
The distribution of atomic minerals in India is sporadic because they are geologically tied to specific rock types and environments. Uranium and thorium minerals are typically found in ancient igneous and metamorphic rocks or concentrated in beach placers. The assertion accurately describes their uneven occurrence, while the reason explains how their formation is strictly controlled by these unique geological associations.

91. (C) It is an igneous rock composed of over 50% carbonate minerals.
A carbonatite is a unique and rare type of igneous rock defined by having a composition of more than fifty percent carbonate minerals, such as calcite or dolomite. They are typically associated with continental rift zones and alkaline igneous provinces. Carbonatites are economically significant because they are major sources of rare earth elements, niobium, and other strategically important minerals.

92. (C) Andhra Pradesh
The Nellore mica belt is a major mica-producing region located in the state of Andhra Pradesh. It is known for its high-quality muscovite mica, which is found in pegmatite veins. For decades, this region has been a significant contributor to India's mica exports and industrial needs. The mining and processing of mica in Nellore are vital for the local and national economies.

93. (D) Tungsten is used as a primary component in manufacturing lightweight aircraft frames.
Chromium is essential for stainless steel, lead is used in batteries, and beryllium is alloyed with copper for non-sparking tools. However, tungsten is not used for lightweight aircraft frames; it is valued for its extreme density and high melting point, making it suitable for cutting tools and filaments. Aluminum and titanium alloys are the primary materials used for lightweight aerospace structures instead.

94. (B) Rock layers containing economically viable concentrations of minerals.
In the context of atomic and other mineral resources, productive horizons" refers to the specific rock layers or geological formations that contain high enough concentrations of minerals to be economically extracted. Identifying these horizons is a key goal of geological exploration and prospecting, as they represent the zones where mining efforts will be most effective and profitable for resource development.

95. (A) Molybdenite
Molybdenite is the primary ore mineral for molybdenum, a metal widely used as an alloying agent in steel to enhance strength and heat resistance. It typically occurs in hydrothermal vein deposits and porphyry complexes. While scheelite and other minerals may contain molybdenum as a trace element, molybdenite remains the most significant source for commercial extraction due to its high molybdenum content.

96. (C) Iron oxides and hydroxides
Ochre pigments are primarily derived from iron oxide and hydroxide minerals, such as hematite, which produces red ochre, and limonite, which produces yellow ochre. These minerals occur naturally in soils and weathered rocks. Their stability, varied colors, and non-toxic properties have made them essential materials for paints and artistic pigments throughout human history and across many diverse global cultures.

97. (B) Both Statement I and Statement II are false.
Both statements are incorrect as they swap the definitions of paragenesis and zoning. Paragenesis refers to the chronological sequence of mineral deposition over time, while zoning refers to the systematic spatial arrangement of minerals within a deposit or region. Understanding both concepts is essential for geologists to reconstruct the complete history and spatial architecture of mineralizing events in the Earth's crust.

98. (C) Assam
The Digboi oilfield is located in the state of Assam and is historically significant as one of the oldest continuously producing oilfields in the world. Operations began in the late nineteenth century, marking the birth of the Indian petroleum industry. Digboi remains a landmark

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116. (C) Inertinite derived from degraded material.
Inertinite is a maceral group in coal derived from plant tissues that have been severely degraded by oxidation, fungal activity, or prehistoric forest fires. As its name suggests, it is generally non-reactive, or inert," during the industrial coking process. This characteristic makes inertinite distinct from the more reactive vitrinite and liptinite groups, which contribute differently to the overall quality and behavior of coal.

117. (B) Monazite (containing Thorium)
The beach sands of Kerala are globally renowned as a major source of monazite, a mineral containing significant amounts of thorium. This heavy mineral is naturally concentrated by wave action into placer deposits. Thorium is a critical element for India's long-term nuclear energy strategy, which aims to utilize its vast thorium reserves to achieve energy independence through advanced nuclear reactor technologies.

118. (B) Arid climate with low rainfall.
An arid climate is least favorable for the formation of rich residual deposits like bauxite. These deposits require intense chemical weathering and leaching of soluble materials, processes that are driven by high rainfall and humid tropical conditions. Without sufficient water to dissolve and carry away unwanted elements, the necessary in-situ enrichment of aluminum or iron oxides will not occur effectively over time.

119. (D) Barite: Vein and replacement deposits, often with sulphides
Barite is commonly found in hydrothermal vein and replacement deposits, where it often occurs alongside sulphide minerals like galena or sphalerite. In contrast, gypsum is an evaporite, asbestos is associated with ultramafic rocks, and graphite typically occurs in high-grade metamorphic rocks. Correctly identifying these major occurrence types is essential for understanding the geological environments in which these non-metallic minerals form.

120. (B) The factors that influence where and why an ore deposit forms.
In economic geology, a control" refers to the specific geological, chemical, or physical factors that dictate the localization and formation of an ore deposit. These can include structural controls like faults, lithological controls like permeable rock layers, or chemical controls such as host rock reactivity. Understanding these controls is essential for mineral exploration, as they help geologists predict where new deposits might be found.

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121. (B) Sulphide deposits
The process of supergene enrichment is most effective for primary sulphide deposits. It occurs when surface waters oxidize minerals like chalcopyrite, leaching the metals and re-precipitating them at or below the water table as secondary sulphides. This can create a highly concentrated zone that is much richer than the original primary ore. This process is a classic mechanism for upgrading low-grade metallic deposits.

122. (D) 1, 2, and 3
Anticlines, unconformities, and salt domes are all effective geological configurations that can act as traps for oil and natural gas. Anticlines provide structural closures, unconformities create stratigraphic traps, and salt domes can deform surrounding rocks into sealed reservoirs. All three features are critical targets in petroleum exploration because they have the potential to confine hydrocarbons and allow for large-scale underground accumulations.

123. (C) Copper and Uranium
The Singhbhum Shear Zone in Eastern India is a major metallogenic province famous for its significant deposits of copper and uranium. This structurally controlled zone hosts several important mines, including Jaduguda for uranium and various copper deposits. The mineralization in this region is essential for India's energy and industrial sectors, making it one of the most important geological features in the country.

124. (C) Caused by ascending fluids from deep within the Earth.
Hypogene mineralization refers to processes driven by fluids that ascend from deep within the Earth's crust, such as hydrothermal solutions or magmatic fluids. These processes form primary ore deposits under conditions of elevated temperature and pressure. This is contrasted with supergene processes, which involve descending

significantly to the industrial development of the state and the national economy as a whole.

159. (C) Gypsum: Weighting agent in drilling mud
Barite is the mineral used as a weighting agent in drilling mud due to its high density. Gypsum, while important for cement and agriculture, does not have the necessary specific gravity for this purpose. Graphite's use in crucibles and mica's role in electrical insulation are both correct. Identifying the specific properties and industrial applications of these minerals is essential for understanding their economic value and market demand.

160. (C) Solar evaporation of seawater or saline lake water
Bedded salt and gypsum deposits form primarily through the solar evaporation of seawater or saline lake water in restricted basins. As the water evaporates, dissolved minerals reach a point of supersaturation and precipitate as distinct layers on the basin floor. This sedimentary process, known as evaporation, is responsible for creating vast deposits of these important industrial minerals in arid and semi-arid regions throughout geological history.

161. (A) 2, 3, 4, 1
The formation of a typical hydrothermal deposit begins with the fracturing of the host rock, creating space for fluids. Early high-temperature minerals like pyrite are deposited first, followed by lower-temperature ore minerals as the system cools. The sequence often concludes with the deposition of late-stage gangue minerals like calcite. This chronological order represents the paragenetic evolution of the mineralization event within the rock mass.

162. (B) 1 and 3 only
India has large reserves of high-grade iron ore and bauxite and possesses globally significant thorium reserves in monazite sands. However, the second statement is incorrect because India is not self-sufficient in copper, lead, and zinc, and must import a significant portion of its requirements for these base metals. This emphasizes the strategic importance of iron, bauxite, and thorium for India's domestic industrial and energy security.

163. (B) Uttar Pradesh
The Narora Atomic Power Station is located in the Bulandshahr district of Uttar Pradesh. It is a major nuclear power facility in northern India, utilizing pressurized heavy water reactors for electricity generation. The station is situated on the banks of the Ganges River and is a key part of India's nuclear energy network, providing power to the northern regional grid to meet industrial and domestic energy needs.

164. (A) In association with serpentinized ultramafic rocks.
Asbestos is most commonly found in association with serpentinized ultramafic rocks, such as serpentinite. These fibrous minerals form through the metamorphic alteration of magnesium-rich parent rocks in the presence of water and heat. While found in various geological settings, this specific association with ultramafic rocks is the primary source for most commercial asbestos varieties, like chrysotile, which were historically mined for their unique physical properties.

165. (A) Both A and R are true and R is the correct explanation of A.
Fluid inclusions are microscopic bubbles of liquid or gas trapped within a mineral during its crystallization. The assertion is correct that studying these inclusions provides critical data on the temperature and chemistry of ancient ore-forming fluids. The reason accurately explains that these inclusions are direct, trapped samples of the original fluid, making them invaluable for reconstructing the environmental conditions during the deposit's formation.

166. (B) Deposition from a colloidal solution or gel at low temperatures.
Colloform texture is characterized by spherical or reniform aggregates with internal concentric banding. This pattern is indicative of rapid mineral deposition from a colloidal solution or gel, typically occurring at relatively low temperatures and pressures. This texture is common in many hydrothermal and sedimentary deposits and provides geologists with important clues about the physical state and chemical environment of the fluids during the mineralization process.

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of uranium and thorium, not copper and lead. While copper and lead are important metallic minerals, they do not possess the radioactive properties necessary for nuclear fission or the production of atomic power in energy reactors.

134. (D) Amethyst (a variety of quartz)
Amethyst is classified as a semi-precious mineral because, while it is beautiful and valued for jewelry, it is relatively abundant compared to precious stones like diamonds or platinum. As a purple variety of quartz, it occurs in various geological environments globally. This classification reflects a combination of its aesthetic appeal, durability, and common occurrence, distinguishing it from the rarest and most expensive precious minerals.

135. (A) Thorium
India possesses some of the world's largest reserves of thorium, primarily located in the monazite sands along its coastal regions. The country's three-stage nuclear power programme is specifically designed to eventually utilize these vast thorium resources as a primary fuel source. Successful implementation of this plan would provide India with long-term energy security and a sustainable, domestic base for large-scale nuclear power generation.

136. (B) A mineral required for defense whose supply is often uncertain.
A strategic mineral is one essential for national defense and key industrial sectors, but whose domestic supply is insufficient or vulnerable to disruption. These minerals are often the subject of government stockpiling and international trade policies. Their strategic" nature stems from the critical role they play in military technology and economic stability, combined with the risks associated with their procurement from foreign sources.

137. (C) Mesh texture
Mesh texture is a distinctive pattern often observed when minerals like olivine are altered to serpentine. It is characterized by a net-like or mesh appearance where the new minerals form along fractures or crystal boundaries, enclosing remnants of the original mineral. This texture provides clear evidence of chemical alteration and hydration processes within ultramafic rocks and is a common feature in many mineralized settings.

138. (C) Sublimation is the most common process for the formation of large, bulk-tonnage ore bodies.
Sublimation involves direct mineral deposition from volcanic gases and is generally limited to small-scale occurrences around vents. It is not the primary process for large, bulk-tonnage ore bodies. Instead, major deposits are typically formed through hydrothermal, magmatic, or sedimentary processes. Metamorphic, sedimentary, and magmatic mechanisms, as described in the other options, are indeed significant ways that large-scale mineral concentrations are created.

139. (D) Khetri
Jharia, Raniganj, and Talcher are all major and historically significant coalfields in India, contributing a vast majority of the country's coal production. Khetri, however, is not a coalfield but a prominent copper mining district located in Rajasthan. This distinction is important for understanding the geographical distribution of India's different energy and metallic mineral resources across its various geological provinces and states.

140. (B) Maturation or Catagenesis
Maturation, also known as catagenesis, is the process by which buried organic matter is thermally converted into petroleum and natural gas through the sustained application of heat and pressure. This occurs as sedimentary basins deepen and the organic material undergoes chemical changes. It is a critical stage in the development of a petroleum system, following diagenesis and preceding the eventual migration of hydrocarbons.

141. (C) Bauxite
The Gandhamardan hills in Odisha are known for hosting significant and high-quality deposits of bauxite. This region is part of India's extensive east coast bauxite belt, which forms some of the largest aluminum ore reserves in the world. The deposits are residual in origin, formed through the intense weathering of underlying rocks, and are a major target for industrial mineral resource development.

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surface waters and weathering at shallow depths. Understanding the hypogene origin is vital for interpreting the initial mineralization event.

125. (C) As a primary structural metal in construction
Silver is highly valued for its electrical conductivity, use in jewelry and silverware, and its historical role in photography. However, it is never used as a primary structural metal in construction due to its high cost and lack of the necessary physical strength for large-scale building frameworks. Structural metals are typically iron, steel, or aluminum, which provide the required durability and economic feasibility.

126. (C) A is true but R is false.
The assertion is correct: coal rank does increase from peat to anthracite as organic matter matures. However, the reason is false because the progression actually involves an increase in carbon content and a decrease in moisture and volatile matter. Higher-rank coals have higher calorific values, contrary to the reason's statement. This relationship between rank and composition is fundamental to coal geology and quality.

127. (D) Beryllium
Beryl is the most important ore mineral for beryllium, a rare metal valued for its low density and high thermal stability. It typically occurs in granitic pegmatites as large, hexagonal crystals. Beryllium extracted from beryl is used in high-tech industries, including aerospace, defense, and nuclear technology. While some beryl varieties are prized as gemstones like emerald, its primary industrial role is as a beryllium source.

128. (B) Large-scale features of an ore body, such as banding or shape.
The structure of an ore refers to its large-scale physical features, such as its overall shape, internal banding, or the presence of massive or disseminated mineralization. While texture describes the microscopic arrangement of grains, structure deals with the macroscopic architectural characteristics of the deposit. These features provide essential information about the conditions of formation and the subsequent geological history of the mineralized rock body.

129. (B) P-3, Q-4, R-2, S-1
Chromite layers in ultramafic rocks represent magmatic segregation. Quartz-gold veins are typical hydrothermal deposits. Bauxite is a classic residual concentration formed through weathering, and gold in river gravels is a prime example of a placer deposit. Correctly matching these examples to their formation processes illustrates the diversity of mechanisms that create economically valuable mineral accumulations in different geological settings.

130. (C) Lead and Zinc
The Rampura-Agucha mine in Rajasthan is one of the world's largest and richest producers of lead and zinc. This massive sulphide deposit occurs in high-grade metamorphic rocks and is mined using sophisticated open-cast and underground methods. Its exceptionally high ore grade and large tonnage make it a critical asset for the Indian mining industry and a significant contributor to the global supply of base metals.

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131. (A) Provide the main source of calcium oxide (lime).
Limestone is the primary raw material in cement manufacturing, providing the essential calcium oxide needed for the production of clinker. During the heating process in a kiln, the calcium carbonate in limestone decomposes to release lime, which then reacts with other components like silica and alumina. This chemical reaction is fundamental to creating the binding properties that define modern cement used in construction.

132. (B) A deposit with a close spatial relationship to volcanic processes.
A volcano genetic deposit is defined by its close spatial and genetic relationship to volcanic activity. This includes deposits formed directly by eruptions, as well as those resulting from associated hydrothermal systems on the seafloor or within volcanic structures. These deposits often host valuable metals like copper, zinc, and gold. Their formation is fundamentally tied to the heat and fluids generated by volcanic systems.

133. (C) Statement I is true, but Statement II is false.
The first statement accurately defines atomic minerals as those used for generating nuclear energy. However, the second statement is false because the primary atomic minerals are ores

body. In contrast, contact metasomatism occurs when fluids and heat from the magma react with and chemically alter the surrounding country rock. While both are related to igneous activity, the location and mechanism of mineral formation are fundamentally different, with one occurring within the intrusion and the other in the host rocks.

151. (A) Regional or contact metamorphism recrystallizing and segregating minerals.
Metamorphic processes like regional or contact metamorphism can concentrate minerals through recrystallization and chemical segregation. For example, high-grade metamorphism of carbon-rich sediments can produce crystalline graphite, while certain aluminous rocks can form garnet-rich zones. These processes occur deep within the Earth's crust under conditions of elevated heat and pressure, transforming pre-existing rocks into new assemblages with potentially economic mineral concentrations.

152. (B) Chromite
Chromite is the most important and primary ore mineral for chromium. It is an oxide mineral typically found in large, layered igneous intrusions associated with ultramafic rocks. Chromium extracted from chromite is essential for the production of stainless steel and various specialized alloys due to its corrosion resistance and hardness. No other mineral serves as a significant commercial source for this strategically important metal.

153. (C) Statement I is false, but Statement II is true.
The first statement is false because India actually has limited reserves of high-quality coking coal, which is essential for steelmaking. Consequently, the second statement is true, as the country is heavily dependent on imports of coking coal to sustain its massive domestic steel industry. This reliance highlights a significant strategic challenge for India's energy and industrial sectors despite its large overall coal reserves.

154. (C) A solid solution mineral unmixed into two separate phases upon cooling.
An exsolution texture forms when a single solid solution mineral becomes unstable during cooling and unmixes into two distinct mineral phases. One mineral typically forms as tiny lamellae or blebs within the host crystal of the other. This relationship provides geologists with important information about the cooling history and initial high-temperature conditions of the ore deposit, indicating that it formed from a homogenous phase.

155. (B) Gujarat
The Ankleshwar oilfield is a major onshore petroleum-producing area located in the state of Gujarat. Discovered in the 1960s, it was one of the first significant oil finds in independent India and played a key role in developing the nation's domestic energy sector. The field produces oil and natural gas from Tertiary sedimentary sequences and continues to be an important contributor to India's energy supply.

156. (C) Layered intrusions of chromite
Layered intrusions of chromite are formed through magmatic segregation, a process that occurs within a cooling magma chamber. In contrast, hydrothermal deposits are characterized by features like veins, stockworks, and wall-rock alteration, which result from the circulation of hot, aqueous mineralizing fluids. While quartz and calcite are common gangue minerals in hydrothermal systems, they are not typically associated with primary magmatic chromite layers.

157. (A) Sylvite (Potash)
Sylvite, commonly referred to as potash, is the primary mineral used as a source of potassium in the fertilizer industry. Potassium is one of the three essential nutrients for plant growth, along with nitrogen and phosphorus. Sylvite is typically found in evaporite deposits formed through the solar evaporation of ancient seawater. Its widespread application in agriculture is critical for maintaining soil fertility and global food security.

158. (C) Iron and Manganese
The Sandur schist belt in Karnataka is an important metallogenic region known for its large and high-grade deposits of iron and manganese. These ores occur in ancient metamorphic rocks and are critical for India's steel and ferroalloy industries. The belt has been a major source of mineral production for decades, contributing

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aqueous fluids are exceptionally effective at leaching, transporting, and depositing metals. The assertion correctly identifies their role in creating copper, lead, and zinc deposits. The reason accurately explains the chemical and physical mechanisms by which these fluids move through the crust and precipitate minerals in response to environmental changes.

108. (B) Minerals fundamental for the functioning of an industrial society.
Essential minerals are those fundamental to the core operations of a modern industrial society, supporting critical sectors like energy, infrastructure, and manufacturing. Without a steady supply of these minerals, a nation's economic and technological stability would be compromised. These resources are distinct from luxury items as they form the basic foundation for national development and the maintenance of essential public services.

109. (C) The process is geologically rapid, taking only a few thousand years.
Petroleum formation is a slow, geologically lengthy process that takes millions of years, rather than just a few thousand. It requires specific conditions, including an anoxic environment for organic matter preservation and long-term thermal maturation of source rocks deep underground. The conversion of kerogen into hydrocarbons is a gradual chemical transformation that occurs over vast timescales as sedimentary basins subside.

110. (B) P-4, Q-3, R-2, S-1
Zinc is primarily extracted from sphalerite, while lead is sourced from galena. Copper's main ore mineral is chalcopyrite, and aluminum is produced from bauxite. Matching these metals to their primary ore minerals is a fundamental aspect of economic geology and mining. Each ore mineral has distinct chemical and physical properties that dictate how the metals are extracted and processed for use.

111. (B) A mineral or fluid inclusion property that constrains the temperature of ore formation.
A geological thermometer refers to a mineral or a characteristic within a mineral, such as a fluid inclusion, that provides information about the temperature at which it formed. By analyzing these features, geologists can determine the thermal conditions of past geological events. This is different from a physical thermometer used to measure current temperatures, as it allows for the reconstruction of ancient environments.

112. (B) Promoting the scientific development of national mineral resources.
The Indian Bureau of Mines is a critical government organization tasked with promoting the scientific development of mineral resources across the country. It regulates mining activities, ensures mineral conservation, and provides technical support for exploration and processing. The bureau works to balance economic extraction with environmental safety, rather than directly operating all mines or solely focusing on the commercial granting of licenses.

113. (A) Hydrocarbon buoyancy relative to the density of formation water.
The primary cause of petroleum and natural gas migration is their buoyancy relative to the denser formation water found within the pores of sedimentary rocks. Because oil and gas are lighter than water, they naturally move upward through permeable rock layers until they are either trapped by an impermeable barrier or reach the Earth's surface. This physical principle drives hydrocarbon movement.

114. (C) Statement I is false, but Statement II is true.
The first statement is false because not all mineral deposits are formed by magmatic processes; many are the result of sedimentary or metamorphic activity. The second statement is true as it correctly acknowledges the vital role that these other geological processes play in creating a wide variety of ore deposits, such as iron formations, evaporites, and concentrations of metamorphic minerals like graphite.

115. (C) Silver
Argentite is a significant ore mineral for silver, consisting of silver sulphide. It is often found in hydrothermal veins, sometimes associated with other silver-bearing minerals or gold. While silver is frequently found in its native form or as a byproduct of lead and zinc mining, argentite is a key mineral source that geologists look for when identifying and evaluating silver-rich mineral deposits.

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167. (B) Galena
Galena is the primary and most important ore mineral for lead. It is a lead sulphide mineral known for its high density, metallic luster, and characteristic cubic cleavage. It typically occurs in hydrothermal vein and replacement deposits, often alongside other metallic ores like sphalerite. Lead extracted from galena is essential for batteries, radiation shielding, and various specialized alloys used across multiple global industrial sectors.

168. (B) P-3, Q-2, R-1, S-4
Vitrain is brilliant and glassy, while clarain is bright and silkily banded. Durain is dull and hard, and fusain is soft and charcoal-like. Matching these lithotypes to their macroscopic characteristics is essential for describing and classifying coal in the field. These distinct appearances reflect the different types of plant material and environmental conditions that contributed to the formation of each band within the coal seam.

169. (C) It is an impermeable rock that prevents the upward escape of petroleum.
A seal or cap rock is a critical component of a petroleum system, consisting of an impermeable rock layer, such as shale or salt, that overlies a reservoir. Its primary function is to prevent the upward migration and escape of hydrocarbons, effectively trapping them underground. Without an effective seal, oil and gas would continue to migrate to the surface and disperse, preventing the formation of an accumulation.

170. (D) Andhra Pradesh
Andhra Pradesh is currently the leading producer of mica in India, with significant deposits located in the Nellore mica belt. The state produces high-quality mica that is valued for its electrical and thermal insulation properties. This mineral is primarily used in the electronics and aerospace industries. India's mica production remains a key part of its global mineral trade, and Andhra Pradesh's contribution is central to this sector.

171. (B) A set of government principles and strategies for managing minerals.
A mineral policy is a formal document or set of principles established by a government to guide the development, management, and conservation of its mineral resources. It outlines strategies for exploration, mining, taxation, and environmental protection. The goal is to ensure that minerals are exploited in a way that benefits the national economy and society while promoting sustainable practices and long-term resource security for the country.

172. (A) Iron and Titanium
Ilmenite is a mineral composed of iron and titanium oxide, making it a primary ore for both metals. In magmatic deposits, it often occurs alongside magnetite. Titanium extracted from ilmenite is valued for its high strength and corrosion resistance, while the iron component adds to the overall value of the ore. This mineral is common in both igneous rocks and as a heavy mineral in beach sand placers.

173. (C) Statement I is false, but Statement II is true.
The first statement is false because placer deposits are not formed by chemical precipitation; they are mechanical concentrations. The second statement is true as it correctly identifies that these deposits consist of heavy, durable minerals like gold and tin that are sorted by gravity in environments like streams or beaches. This mechanical sorting process is fundamentally different from the chemical mechanisms that form evaporites or hydrothermal veins.

174. (C) Karnataka
The Hutti Gold Mine is a major gold-producing center located in the state of Karnataka. It is one of the few active gold mines in India and has a long history of production. The mine utilizes modern underground mining and processing technologies to extract gold from metamorphic rocks. Along with the historical Kolar Gold Fields, the Hutti mine represents a key part of India's geological and economic heritage in gold mining.

175. (D) Anthracite
Anthracite is the highest rank of coal, possessing the greatest carbon content and highest calorific value of all coal varieties. It is characterized by its hard, black appearance and a bright, metallic luster. Anthracite forms under conditions of extreme heat and pressure during the coalification process. Because of its high energy density and low impurity content, it is valued for

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specialized industrial uses and high-efficiency energy production.

176. (B) Formation of Banded Iron Formations (BIFs)
Banded Iron Formations are classic examples of sedimentary deposits, formed by the chemical precipitation of iron-rich and silica-rich layers in ancient marine environments. This process occurred on a massive scale billions of years ago. In contrast, contact metasomatism and magmatic segregation are related to igneous activity, and pegmatites are igneous rocks. BIFs are the primary global source of iron ore and are fundamental to the global steel industry.

177. (B) It can be thermogenic, formed deep within the earth, or biogenic.
Natural gas can originate from two primary processes: thermogenic, where organic matter is broken down by heat at great depths, or biogenic, where specialized bacteria produce methane at shallow depths and lower temperatures. While often associated with oil, natural gas can also occur independently. It is a highly versatile hydrocarbon fuel that exists in a gaseous state at standard surface conditions, making it distinct from liquid crude oil and solid coal.

178. (C) High electrical conductivity and high melting point (refractoriness).
Graphite's primary industrial uses are based on its unique combination of high electrical conductivity and high melting point, also known as refractoriness. These properties make it ideal for use in electrodes, lubricants, and high-temperature crucibles. Additionally, its layered crystalline structure allows it to function as an effective dry lubricant. This versatile mineral is essential for metallurgy, chemical processing, and the manufacturing of modern batteries and electronic components.

179. (C) The uppermost part of the deposit (gossan) where sulphides are altered to oxides and carbonates.
The oxide zone refers to the uppermost, weathered part of a sulphide deposit, also known as a gossan. In this zone, primary sulphide minerals have been oxidized and altered into secondary oxides, hydroxides, and carbonates. This process often results in the leaching of valuable metals, which may then move downward to form supergene enrichment zones. The oxide zone provides critical visual clues for geologists to locate buried ore bodies.

180. (C) As an alloy in steelmaking
Manganese is an indispensable element in modern industry, where its primary use is as an alloying agent in steelmaking. It helps remove sulfur and oxygen from molten steel and significantly increases the metal's toughness, hardness, and overall strength. Nearly ninety percent of global manganese consumption is dedicated to the iron and steel industry, making it a critical component of infrastructure and manufacturing sectors worldwide.

181. (D) 1, 2, and 3
Uranium occurs in the Singhbhum Shear Zone, while thorium is sourced from monazite in coastal sands. The Department of Atomic Energy is the responsible authority for these minerals. All three statements accurately describe the locations, sources, and administrative oversight of atomic minerals in India. These resources and their management are critical for the nation's energy security and the development of its nuclear power infrastructure.

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182. (A) Biogenic sedimentary deposit
A biogenic sedimentary deposit forms from the accumulation and lithification of organic remains, such as shells, skeletons, and other biological debris. Over time, these materials are buried and compacted to form rocks like fossiliferous limestone. This process is common in marine environments where biological activity is high. These deposits are important indicators of past environmental conditions and can sometimes host valuable resources like oil or gas.

183. (B) Porphyry copper deposit
The Malanjkhand deposit in Madhya Pradesh is a prominent example of a porphyry copper deposit in India. It is characterized by large tonnage and relatively low ore grades, with mineralization occurring as disseminations and stockwork veins in granitic host rocks. This type of deposit is a major global source of copper and is typically mined on a large scale using open-cast methods to ensure economic viability.

184. (A) Both A and R are true and R is the correct explanation of A.
Studying the paragenetic sequence is vital for understanding how an ore deposit evolved. The assertion correctly states its importance, while the reason explains that the sequence reveals the changing environmental conditions during mineralization by showing the chronological order of mineral deposition. This information helps geologists reconstruct the hydrothermal or magmatic history of the system, which is essential for both scientific research and effective exploration.

185. (A) Onshore oil and gas fields
The Cambay Basin in Gujarat is one of India's major petroliferous basins, primarily known for its numerous onshore oil and gas fields. Exploration in this region began in the 1950s and led to several significant discoveries that established Gujarat as a key center for the Indian energy industry. The basin's Tertiary sedimentary sequences continue to provide substantial hydrocarbons, supporting the state's industrial and economic development.

186. (C) It is abundantly produced domestically.
A critical mineral is one that is essential for modern technology and the economy but whose supply is at high risk of disruption, often because it is NOT abundantly produced domestically. These minerals are vital for high-tech manufacturing, green energy, and national security. Ensuring a stable supply through exploration or international agreements is a major priority for countries that lack significant domestic reserves of these resources.

187. (A) P-3, Q-1, R-4, S-2
A source rock generates hydrocarbons, which are then stored in a porous reservoir rock. An impermeable cap rock prevents escape, and the entire trap configuration confines the petroleum. Correctly defining these terms is fundamental to petroleum geology and exploration. Each component plays a unique and necessary role in the formation and preservation of extractable oil and gas accumulations within a sedimentary basin's architecture.

188. (C) Intense tropical weathering of ultramafic rocks.
Lateritic nickel deposits form through the intense chemical weathering of nickel-bearing ultramafic rocks in humid tropical environments. High rainfall and temperature cause the leaching of silica and magnesium, while nickel and iron are concentrated in the residual soil or laterite. This process of secondary enrichment creates economically viable nickel ores from parent rocks that originally contained much lower concentrations of the metal.

189. (B) Vitrain is derived from woody tissue, while fusain is charcoal-like, often from fires.
Vitrain and fusain are both lithotypes of coal but have very different origins and appearances. Vitrain is brilliant, black, and glassy, typically derived from the woody tissues of ancient plants. In contrast, fusain is dull, black, and charcoal-like, believed to form from plant material partially burnt in prehistoric forest fires. These differences in origin and physical properties are essential for classifying coal and understanding its banded structure.

190. (B) As a soil conditioner providing essential calcium and sulfur minerals.
In agriculture, gypsum is primarily used as a soil conditioner to improve soil structure and provide essential nutrients like calcium and sulfur. It is particularly effective in treating sodic soils, where it helps remove excess sodium and improves water infiltration. By enhancing soil health and nutrient availability, gypsum application supports better crop growth and increased yields, making it a valuable tool for sustainable agricultural practices and land management.

191. (B) Magnetite iron ore
The Kudremukh deposits in Karnataka were famous for hosting vast reserves of magnetite iron ore. These deposits occur in ancient metamorphic rocks and were once mined on a large scale for export. Although large-scale mining has been discontinued due to environmental concerns, the region remains an important geological landmark for iron mineralization in India and reflects the country's diverse range of metallic ore occurrences.

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192. (C) Statement I is false, but Statement II is true.
The first statement is false because many significant ore deposits are located at depth and have no obvious surface expression. The second statement is true, as these blind" deposits require sophisticated geological, geophysical, and geochemical methods for discovery. Modern exploration relies heavily on these indirect technologies to identify potential mineral wealth that cannot be seen through direct visual observation or traditional prospecting techniques.

193. (C) Bonai-Keonjhar belt
The Keonjhar district in Odisha is part of the famous Bonai-Keonjhar belt, one of India's richest and most important iron ore provinces. This region hosts massive deposits of high-grade hematite, which are essential for the country's domestic steel industry and international trade. The belt's geological formations represent some of the world's most significant iron accumulations, making it a critical hub for the national mining sector.

194. (A) Zinc
Zinc is the primary metal alloyed with copper to produce brass. This versatile alloy is valued for its strength, corrosion resistance, and aesthetic appeal, and is used in plumbing, musical instruments, and decorative items. Zinc also plays a major role in galvanizing iron and steel to prevent rust. Its properties as an alloying agent are fundamental to many industrial and manufacturing processes globally, supporting a wide range of applications.

195. (B) Whether it is optically isotropic or possesses anisotropic properties.
In ore microscopy, anisotropism is an optical property that reveals whether a mineral's crystalline structure is isotropic (the same in all directions) or anisotropic. This is observed by rotating the mineral under crossed polarizers in reflected light. This feature is essential for mineral identification, as it allows geologists to distinguish between minerals that may appear similar under plane-polarized light but have different structural symmetries.

196. (B) The Gondwana Supergroup
The Gondwana Supergroup is the primary geological formation hosting the vast majority of India's coal reserves. These sedimentary rocks were deposited in large basins during the Permian period and contain thick, economically significant coal seams. Most of India's major coalfields, such as Jharia and Raniganj, are found within this group. The Gondwana coal is essential for the country's energy production and industrial sectors, particularly for power generation and steelmaking.

197. (B) The order of formation of minerals over time in an ore deposit.
Paragenetic sequence refers to the chronological order in which various minerals are formed and deposited within an ore body. It represents the temporal evolution of the mineralization event. By studying this sequence through microscopic examination of mineral intergrowths and textures, geologists can reconstruct the history of the deposit and understand how environmental conditions, such as temperature and fluid chemistry, changed over time.

198. (C) Manganese ore
The Balaghat district of Madhya Pradesh is India's leading producer of manganese ore. The region hosts large and high-quality deposits that occur in ancient metamorphic rocks of the Sausar Group. Manganese is a critical element for the steel industry, and Balaghat's mines are essential for meeting both domestic demand and international exports. The district is a major hub for manganese mining and processing in the country.

199. (A) A skarn or contact metasomatic deposit.
A skarn, or contact metasomatic deposit, forms when mineral-rich fluids from an igneous intrusion react with and replace a reactive host rock, such as limestone. This chemical exchange leads to the formation of new minerals, often including valuable ores of tungsten, copper, or iron. This process is characterized by intense chemical alteration and is a common mechanism for creating economically significant mineral concentrations in contact zones.

200. (C) As a filament in incandescent light bulbs.
Zinc is widely used for galvanizing steel, making alloys like brass, and in die-castings for various components. However, it is never used as a filament in incandescent light bulbs; tungsten is

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used for this purpose due to its extremely high melting point and durability. Zinc's physical and chemical properties make it more suitable for protection against corrosion and as a structural component in many industrial and domestic applications.

201. (C) Lateritization of khondalites and charnockites
The extensive bauxite deposits along the east coast of India are residual in origin, formed through the intense weathering and lateritization of ancient metamorphic rocks like khondalites and charnockites. This process involves the leaching of soluble components under tropical conditions, leaving behind a concentrated layer of aluminum oxides. These deposits represent some of India's largest and most valuable aluminum ore reserves, supporting a major domestic industry.

202. (D) 1, 2, and 3
Mineral deposits are classified based on their formation processes: magmatic deposits from magma, hydrothermal from hot fluids, and sedimentary at or near the surface. All three statements correctly describe these fundamental genetic categories. This classification system provides geologists with a structured way to understand the origin, properties, and geological settings of various types of mineral occurrences, which is essential for effective exploration and resource management.

203. (C) Caused by descending surface waters, typically involving weathering.
Supergene mineralization refers to geological processes driven by descending surface waters, primarily involving the weathering and oxidation of pre-existing mineral deposits. These waters leach metals from the upper zones and re-precipitate them at or below the water table, often creating concentrated secondary zones. This process is essential for upgrading low-grade primary ores and is fundamentally different from hypogene processes that involve ascending deep-seated fluids or igneous activity.

204. (A) Zinc
Sphalerite is the primary and most important ore mineral for zinc. It is a zinc sulphide mineral that typically occurs in hydrothermal vein and replacement deposits, often associated with galena. Zinc extracted from sphalerite is essential for galvanizing steel, making brass, and in various chemical and industrial applications. This mineral is the backbone of the global zinc industry and is found in major mining districts worldwide.

205. (A) Both A and R are true and R is the correct explanation of A.
The rank of coal is a direct measure of its coalification or metamorphic maturity. The assertion correctly identifies this relationship. The reason accurately explains that as rank increases, the proportion of fixed carbon rises while moisture and volatiles decrease. This chemical transformation increases the energy density of the coal, making rank a fundamental factor in determining the industrial quality and energy potential of different coal deposits.

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206. (A) Bauxite and Ilmenite
The Ratnagiri district of Maharashtra is known for its significant coastal deposits of bauxite and ilmenite. Bauxite occurs as a residual weathering product, while ilmenite is found in beach sand placers. These minerals are important for the aluminum and titanium industries, respectively. The region's geological setting and coastal environment facilitate the formation and concentration of these ores, contributing to the state's diverse mineral resource base.

207. (B) A restricted basin in an arid climate where evaporation exceeds inflow.
The formation of an evaporite deposit requires a restricted basin in an arid climate where the rate of evaporation is significantly higher than the inflow of fresh water or seawater. This causes dissolved minerals, such as halite or gypsum, to reach supersaturation and precipitate as solid layers. This environment is essential for creating thick sequences of evaporite minerals, which are important resources for many chemical and industrial sectors.

208. (B) P-2, Q-4, R-3, S-1
Asbestos is fibrous and found in serpentinites. Barite has an unusually high specific gravity for a non-metallic mineral. Graphite is very soft and marks paper, while gypsum is also very soft and commonly forms in evaporite sequences. Correctly matching these minerals to their key properties or associations is fundamental for

their identification and understanding their diverse industrial and geological roles across various sectors.

209. (C) Petroleum
'Rock oil' is an old and literal name for petroleum, derived from the Latin words 'petra' (rock) and 'oleum' (oil). This term reflects the natural occurrence of hydrocarbons within the pores and fractures of sedimentary rocks. While now most commonly called petroleum or crude oil, the name 'rock oil' historically distinguished this naturally occurring substance from oils derived from animals or plants, highlighting its geological origin.

210. (A) Beryl
Beryl is a primary and essential ore mineral for beryllium, a rare metal valued for its lightness and strength. While some varieties of beryl are prized as gemstones, such as emerald and aquamarine, its industrial importance lies in its beryllium content. Beryl is typically found in granitic pegmatites. Bauxite is an ore of aluminum, barite of barium, and bornite is a copper sulphide mineral, making them distinct from beryllium ores.

211. (C) Oxidation and supergene sulphide enrichment
The process of oxidation and supergene sulphide enrichment involves acidic surface waters percolating downward through a mineral deposit. These waters leach metals from the upper oxidized zone and re-precipitate them at or below the water table, creating a richer secondary zone of minerals like chalcocite. This weathering process is critical for upgrading primary ore deposits into economically extractable resources, particularly for metallic minerals like copper.

212. (C) Statement I is true, but Statement II is false.
The first statement is true as the Krishna-Godavari Basin is indeed a major area for India's deep-water gas reserves. However, the second statement is false because petroleum exploration in India is not exclusive to ONGC; other public and private sector companies also play significant roles. This competitive landscape is part of India's policy to enhance energy security through diverse exploration and production activities by multiple entities.

213. (A) Contact metasomatism involving carbonate-rich host rock bodies.
A skarn is a type of ore deposit formed through contact metasomatism, specifically where fluids from an igneous intrusion react with carbonate-rich host rocks like limestone or dolomite. This process results in a complex mineral assemblage that can host valuable ores of tungsten, copper, lead, zinc, and iron. Skarn deposits are important global sources of these metals and are characterized by intense chemical and mineralogical changes in the host rock.

214. (B) In the manufacture of phosphate fertilizers
Apatite is primarily valued as the main source of phosphorus for the manufacturing of phosphate fertilizers. Phosphorus is an essential nutrient for plant growth and agricultural productivity. While some apatite varieties are used as gemstones or abrasives, its most significant economic and industrial role is in the agricultural sector. The extraction and processing of apatite from various rock types are critical for ensuring global food security.

215. (C) Manganese
The 'Gondite series' refers to a group of metamorphosed sedimentary rocks exceptionally rich in manganese, found primarily in Madhya Pradesh and Maharashtra. These rocks are a major source of India's manganese production and are critical for the steel industry. The term reflects the geological association of these ores with ancient sedimentary sequences that have undergone significant metamorphism, resulting in large and economically valuable concentrations of manganese minerals.

216. (A) An anticline
An anticline is a classic example of a structural trap for petroleum. It is an upward-arching fold in rock layers that can trap migrating hydrocarbons within its crest if capped by an impermeable rock layer. This geometric configuration provides a reliable and often large-scale underground container for oil and natural gas. Anticlines are primary targets for petroleum exploration worldwide due to their potential to hold significant extractable hydrocarbon accumulations.

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217. (D) Mica
Limestone, clay/shale, and gypsum are all essential raw materials in the cement industry. Limestone provides lime, clay provides silica and alumina, and gypsum controls the setting time. Mica, however, is not used in the primary manufacturing of cement; it is instead valued as an electrical insulator or in pigments. The specific chemical and physical requirements of cement production dictate the use of certain minerals over others during industrial processing.

218. (C) Tin
The Tosham hill area in Haryana is well-known for its mineralization of tin. This region hosts one of India's few significant occurrences of tin, which is found associated with granitic igneous rocks. Exploration in the area has identified cassiterite, the primary ore mineral of tin. This deposit represents an important potential resource for the country's domestic metal needs and is a focus for geological research and mineral assessment.

219. (C) Minimum grade required for a mineral to be economically mineable.
The cut-off grade is the minimum concentration of a mineral required for it to be economically viable to mine and process. Any material with a grade below this limit is considered waste rock or gangue. This grade is determined by factors like mineral prices, mining costs, and processing efficiency. It is a critical parameter in mine planning and resource evaluation, as it defines the boundaries of the exploitable ore body.

220. (C) Geophysical methods like Induced Polarization (IP) and Electromagnetics (EM)
For buried sulphide ore bodies with no surface expression, geologists rely on geophysical methods like Induced Polarization and Electromagnetics. These technologies detect the physical properties of minerals, such as electrical conductivity and chargeability, through the overlying rock and soil. These indirect methods are essential for modern mineral exploration, allowing for the discovery of blind" deposits that cannot be found through visual observation or traditional surface prospecting techniques.

221. (C) Durain composed of the inertinite group.
Durain is a lithotype of coal characterized by its hard, dull, and granular appearance. It is primarily composed of the inertinite maceral group, along with some liptinite and mineral matter. This composition makes it more resistant and less reactive during industrial processes compared to bright coal lithotypes like vitrain. Understanding these macroscopic and microscopic characteristics is vital for assessing coal quality and its potential behavior during coking or power generation.

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222. (A) At the same time as the host rock.
A syngenetic ore deposit is one that formed at the same time as the host rock that contains it. Examples include sedimentary iron formations or magmatic segregation deposits. In these cases, the mineralization and the formation of the surrounding rock are parts of the same geological event. This is contrasted with epigenetic deposits, which are introduced into pre-existing rocks long after they have formed, such as hydrothermal veins.

223. (A) 1, 2, 3
Gravity settling in a magma chamber forms magmatic concentration deposits. Precipitation from circulating fluids in fractures creates hydrothermal deposits, and mechanical sorting in river systems results in placer deposits. These three processes represent fundamentally different geological mechanisms for concentrating minerals. Understanding these distinctions is essential for geologists to correctly identify, classify, and explore for various types of mineral resources across different crustal environments and geological settings.

224. (B) After the formation of its host rock.
An epigenetic mineral deposit is one that formed after its host rock was already in place. These deposits are typically introduced by fluids, such as hydrothermal solutions, that circulate through fractures, pores, or faults in pre-existing rocks. Examples include gold-quartz veins or replacement deposits. This term is the opposite of syngenetic, where the ore and rock form simultaneously, and it is a fundamental classification in the study of ore genesis.

225. (A) Both A and R are true and R is the correct explanation of A.
The presence of tourmaline and topaz in a vein deposit strongly suggests a close association with a granitic intrusion. The assertion correctly identifies this indicator. The reason accurately explains that these minerals are rich in boron and fluorine, volatile elements that concentrate in the final fluids of cooling granitic magmas. This chemical relationship provides geologists with vital clues about the origin and source of mineralizing fluids in many hydrothermal systems.

226. (C) They mediate chemical reactions causing the mineral precipitation.
Bacteria play a crucial role in the formation of certain mineral deposits by mediating chemical reactions that cause minerals to precipitate. For example, sulfur-reducing bacteria can facilitate the formation of pyrite, while other types are involved in the accumulation of bog iron ores. This biogenic mineralization occurs at or near the Earth's surface and is an important process in many sedimentary and aquatic environments, contributing to various mineral resource formations.

227. (B) A lease to undertake mining operations and extract minerals.
In India's mineral concession rules, a mining lease is a legal right granted by the government that allows a person or company to undertake mining operations and extract minerals from a specified area. It follows the successful identification of a mineral resource through prospecting. The lease specifies the terms, conditions, and duration of the mining activity, ensuring that the resources are exploited in a regulated, scientific, and environmentally responsible manner.

228. (A) P-3, Q-4, R-1, S-2
Hematite is iron oxide, chalcopyrite is copper iron sulphide, galena is lead sulphide, and sphalerite is zinc sulphide. Matching these ore minerals to their correct chemical formulas is fundamental in mineralogy and economic geology. These formulas reflect the chemical composition and crystal structure of the ores, which dictate their properties and the specific metallurgical processes required to extract the valuable metals they contain for industrial use.

229. (C) Lignite
The Neyveli deposits in Tamil Nadu are India's primary source of lignite, a lower-rank coal with high moisture content. These large-scale open-cast mines support several thermal power stations, providing a critical source of electricity for the southern region. The Neyveli Lignite Corporation manages these operations, which are essential for meeting the energy demands of the state and the national power grid using this domestic fuel resource.

230. (C) Iron Ore
The Chikmagalur district in Karnataka is well-known for its significant deposits of iron ore, particularly in the Bababudan hills. This region was the site of some of India's earliest and most important iron mining activities. The ore, primarily magnetite and hematite, occurs in ancient metamorphic rocks and has been a major contributor to the state's industrial development. The region remains a key area for geological study and mineral resource assessment.

231. (B) The percentage of fixed carbon and volatile matter
The rank of coal is primarily defined by the percentage of fixed carbon and volatile matter it contains. As coal matures through heat and pressure, the carbon content increases while moisture and volatiles decrease. This chemical transformation increases the energy density and calorific value of the coal, determining its rank from peat to anthracite. This maturity level is a fundamental factor in assessing the quality and potential industrial applications of any coal deposit.

232. (A) Both Statement I and Statement II are true.
Gold is frequently found in nature in its native metallic form, as stated in the first sentence. Furthermore, the second statement is true because gold's exceptionally high density and chemical inertness allow it to withstand weathering and be concentrated by gravity in placer deposits. These two factors explain why gold is both found in primary veins and easily recovered from secondary environments like riverbeds and beach sands throughout the world.

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233. (D) High-grade coking coal
Rajasthan is a major producer of lead, zinc, copper, gypsum, and asbestos, hosting several of India's most important mines for these minerals. However, it is not a significant producer of high-grade coking coal; India's major coking coal reserves are concentrated in the eastern states like Jharkhand. This distinction reflects the different geological provinces within India, where Rajasthan's mineral wealth is primarily metallic and non-metallic, rather than energy-based coal resources.

234. (B) Pneumatolytic to hydrothermal
The association of cassiterite with granite and pegmatites represents a mineralization process ranging from pneumatolytic (involving gases) to hydrothermal (involving hot water). These processes occur during the late stages of magmatic cooling, where volatile-rich fluids concentrate and transport metals like tin. Cassiterite precipitates as the fluids cool or react with host rocks, forming vein and replacement deposits. This geological setting is characteristic of most major primary tin occurrences globally.

235. (B) Hydrogenous/Authigenic sedimentary deposits
Manganese nodules and other mineral resources on the deep-sea floor are examples of hydrogenous or authigenic sedimentary deposits. They form through the slow chemical precipitation of minerals directly from seawater onto the ocean floor over millions of years. These nodules contain significant amounts of manganese, iron, nickel, cobalt, and copper. While not yet widely mined, they represent a vast potential future resource for strategically important metals found in the global ocean basins.

236. (B) To ensure scientific mining with a focus on environmental conservation.
The primary role of the Mineral Conservation and Development Rules in India is to ensure that mining operations are conducted in a scientific and systematic manner with a strong emphasis on environmental conservation. These rules provide the regulatory framework for protecting the environment, ensuring the proper restoration of mined land, and maximizing the recovery of mineral resources while minimizing waste and preventing unscientific or haphazard mining practices across the country.

237. (B) Iron ore, Tin, and Bauxite
The Bastar Craton in Central India is a major mineral-rich geological province known for its significant deposits of iron ore, tin, and bauxite. The region hosts some of the world's highest-grade hematite deposits and is also the only significant source of primary tin in India. These mineral resources are essential for the country's industrial development and energy security, making the Bastar Craton one of India's most important metallogenic regions.

238. (A) Wolframite and Scheelite
Wolframite and scheelite are the two most important ore minerals for tungsten. Wolframite is an iron-manganese tungstate, while scheelite is a calcium tungstate. Both minerals are typically found in high-temperature hydrothermal veins and pegmatites associated with granitic rocks. Tungsten extracted from these ores is valued for its extreme hardness and high melting point, making it critical for various industrial, military, and high-performance engineering applications across multiple sectors.

239. (C) Temperature and duration of burial.
The conversion of organic matter into kerogen and subsequently into oil and gas is primarily controlled by the temperature and the duration of burial. As organic-rich sediments are buried deeper, increasing heat triggers chemical reactions that break down complex molecules into hydrocarbons. The specific range of temperature and time required is often referred to as the oil window." This maturity process is fundamental to the generation of extractable petroleum resources.

240. (B) A natural mineral from which a valuable part can be extracted at a profit.
An ore is defined as a naturally occurring mineral or rock from which a valuable component, typically a metal, can be extracted at a profit. This definition includes both geological and economic factors; if the extraction cost exceeds the value of the material, it is not considered an ore. The term implies that the mineral concentration is high enough to justify the industrial processes required for mining and metallurgical recovery.

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241. (C) As a coating for steel and in alloys such as solder and bronze.
Tin's principal use is as a protective coating for steel, particularly in tinplate for food containers, and as a major component in alloys like solder and bronze. Its corrosion resistance and low toxicity make it ideal for these applications. While it has minor uses in chemicals and glass, its role in metallurgy and packaging remains its most significant global economic contribution. This metal is essential for electronics, infrastructure, and the food industry.

242. (B) Uranium, Copper, Chromite
Jaduguda is famous for uranium, Khetri for copper, and Sukinda for chromite. Correctly identifying these iconic mining locations and their respective primary mineral products reflects an understanding of India's major metallogenic provinces. Each of these regions plays a critical role in providing essential materials for the nation's energy, industrial, and manufacturing sectors, and they are foundational sites for the Indian mining and metallurgical industries.

243. (A) Its layered structure with weak bonds allows layers to slide easily.
Graphite is used as a lubricant because of its unique layered crystalline structure. Within each layer, carbon atoms are strongly bonded, but the bonds between layers are very weak. This allows the layers to slide over each other with very little friction, making it an excellent dry lubricant even under high-temperature or high-pressure conditions. This property is fundamental to its application in machinery, automotive parts, and various industrial equipment.

244. (C) Kota (at Rawatbhata)
The Rajasthan Atomic Power Station is located at Rawatbhata, near the city of Kota. This facility is a major hub for nuclear power generation in India, utilizing multiple pressurized heavy water reactors. Its location near the Rana Pratap Sagar dam provides necessary water for cooling. The station is a key contributor to the northern power grid and represents a significant achievement in India's nuclear energy development and domestic power generation capabilities.

245. (A) Both A and R are true and R is the correct explanation of A.
The Damodar Valley in eastern India is frequently called the Ruhr of India." The assertion correctly identifies this title. The reason accurately explains that the region's immense coal wealth and the resulting concentration of industries are analogous to the Ruhr region in Germany. This comparison highlights the valley's critical role as India's primary industrial heartland, driven by its vast energy resources and well-developed infrastructure for manufacturing and metallurgy.

246. (A) A swampy or deltaic environment with rapid plant material burial.
The genesis of coal requires a swampy or deltaic environment where terrestrial plant matter can accumulate and be rapidly buried under anaerobic conditions. This prevents the decay of the organic material. Over geological time, heat and pressure from subsequent sedimentation transform this debris into various ranks of coal. This specific depositional setting is essential for preserving the organic carbon necessary to form economically significant coal deposits in sedimentary basins.

247. (B) Uranium
Pitchblende is a primary ore mineral for uranium, consisting of uranium oxide. It is a highly radioactive mineral and has been the main source of uranium for research and power generation since its discovery. In India, uranium minerals are found in various geological settings, including the Singhbhum Shear Zone. Pitchblende's high uranium content makes it the most significant target for uranium exploration and mining globally, supporting the nuclear energy industry.

248. (B) P-4, Q-1, R-3, S-2
Contact metasomatism on limestone forms skarn deposits. Residual weathering in the tropics produces bauxite. Evaporation of brine creates rock salt, and magmatic segregation is responsible for deposits like the nickel-copper sulphides at Sudbury. Matching these geological processes with their resulting mineral deposits is fundamental to understanding ore genesis and helps geologists identify potential mining targets by recognizing characteristic environmental and genetic features across diverse geological settings.

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249. (B) Magma can be the source of heat, fluids, and metals for a wide variety of ore deposits.
Magma plays a critical role in mineral deposit formation by serving as a source of heat, mineralizing fluids, and dissolved metals. These elements can be concentrated within the magma itself or transported into the surrounding rocks to form hydrothermal, pegmatitic, or contact metasomatic deposits. This relationship is fundamental to economic geology, as many of the world's most valuable metallic resources are genetically linked to magmatic systems and their associated processes.

250. (B) The eventual use of thorium-based fuel in the third stage.
A key component of India's three-stage nuclear power programme is the eventual large-scale use of its vast thorium reserves as fuel in the third stage. The first two stages, utilizing uranium and plutonium in pressurized heavy water and fast breeder reactors, are designed to create the necessary conditions and fuel to initiate the thorium cycle. This strategic plan aims to achieve long-term energy independence by leveraging India's most abundant nuclear resource.

251. (B) Chemical and mineralogical changes in host rock due to ore fluids.
Wall rock alteration refers to the chemical and mineralogical changes that occur in the host rock surrounding a hydrothermal ore deposit. These changes are caused by the reaction between the hot, mineralizing fluids and the wall rock as the fluids circulate through fractures. These alteration patterns, such as silicification or sericitization, often cover a larger area than the ore itself, providing valuable halos" or indicators that geologists use to locate buried ore bodies.

252. (C) Statement I is true, but Statement II is false.
The first statement is true as India's National Mineral Policy does promote a 'zero-waste' mining approach to ensure resource efficiency. However, the second statement is false because this approach specifically involves maximizing the use of all excavated material, including low-grade ores and associated minerals, rather than ignoring them. The goal is to minimize waste and environmental impact while increasing the overall value and sustainability of the mining operations nationwide.

253. (B) Karnataka
The Byrapur chromite deposits are located in the state of Karnataka. These deposits are associated with ancient ultramafic rocks and have been a significant source of chromite in southern India. Chromite is essential for the production of ferro-alloys and stainless steel. The Byrapur mines contribute to the state's diverse mineral resource base and the national supply of this strategically important metallic ore, which is vital for many modern industrial and metallurgical applications.

254. (C) Low to moderate temperature hydrothermal deposition
Native silver deposits found in veins with cobalt-nickel arsenides are typically the result of low to moderate temperature hydrothermal deposition. These fluids transport silver and other metals through fractures in the crust and precipitate them as temperatures and pressures drop. This specific mineral association is a classic example of a five-element vein" type deposit, which provides important clues about the chemical environment and geological history of the mineralizing system during its formation.

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255. (B) Macroscopic, visually distinct bands of coal
In coal studies, lithotypes are the macroscopic bands that are visually distinct within a coal seam. These include varieties like vitrain, clarain, durain, and fusain. Each lithotype has unique physical properties such as luster, color, and fracture, which reflect the original plant material and environmental conditions of deposition. Identifying lithotypes is a fundamental step in describing and classifying coal during field investigations or hand specimen examination of large-scale coal samples.

256. (C) Fossilization
Fossilization is a biological and taphonomic process that preserves organic remains, but it is not a primary mechanism for creating economically significant ore deposits. In contrast, metamorphic remobilization, hydrothermal deposition, and magmatic concentration are all fundamental geological processes that concentrate minerals into valuable ore bodies. While fossils can be found within some mineral deposits, the act of fossilization itself does not generate large-scale accumulations of metallic or industrial minerals for mining.

272. (C) Statement I is false, but Statement II is true.
The first statement is false because placer deposits are formed by mechanical processes, not chemical precipitation. The second statement is true as it accurately identifies that placers are concentrations of heavy, durable minerals like gold, tin, and diamond, formed by gravity sorting in high-energy environments like streams or beaches. This mechanical concentration is a fundamental geological process for creating many of the world's most accessible and historically significant metallic and gemstone mineral deposits.

273. (B) Rajasthan
The Debari Zinc Smelter is located in the state of Rajasthan, near Udaipur. It is one of India's largest and most important facilities for the smelting and refining of zinc. The smelter processes ore from nearby mines, such as those in the Zawar and Rampura-Agucha belts. Its presence in Rajasthan highlights the state's dominant role in India's lead and zinc industry, providing essential refined metals for various domestic and international industrial and manufacturing sectors.

274. (C) Minerals
In coal petrology, macerals are the microscopic organic constituents that are functionally analogous to minerals in inorganic rocks. Just as rocks are composed of various minerals that determine their properties, coal is made of different macerals like vitrinite, liptinite, and inertinite. Studying these macerals under a microscope is essential for assessing coal quality, maturity, and its suitability for various industrial applications, such as coking or power generation in thermal power plants.

275. (B) A sudden drop in pressure or temperature causing supersaturation.
A sudden drop in pressure or temperature is a key physical control on ore deposition from hydrothermal fluids. As hot, mineral-rich solutions move into cooler or lower-pressure environments, the solubility of dissolved metals decreases, causing them to reach supersaturation and precipitate as solid minerals. This physical mechanism is responsible for the formation of most vein and lode deposits, as fluids interact with the cooler host rocks and the surrounding geological environment.

276. (C) Granite pegmatite
The occurrence of beryl, spodumene, and lepidolite in an extremely coarse-grained igneous rock is highly characteristic of a granite pegmatite. These rocks form from the volatile-rich final stages of granitic magma crystallization, allowing for the growth of massive crystals and the concentration of rare elements like lithium and beryllium. Granite pegmatites are globally important sources of these strategically valuable minerals and are prized for their unique mineralogy and industrial significance in various high-tech sectors.

277. (C) Secondary migration and accumulation
The downward movement and eventual accumulation of petroleum into a trap is referred to as secondary migration and accumulation. This follows primary migration, which is the expulsion of hydrocarbons from the source rock. Secondary migration occurs through permeable carrier beds and is driven by buoyancy and pressure. When the hydrocarbons encounter an impermeable seal or a trap configuration, they accumulate to form extractable pools. This process is the final step in creating an oil or gas deposit.

278. (C) High specific gravity
Barite's primary use in the petroleum industry is as a weighting agent in drilling mud, a function that relies on its remarkably high specific gravity for a non-metallic mineral. When added to drilling fluid, barite increases the mud's density, helping to balance high underground fluid pressures and prevent blowouts during oil and gas exploration. Its chemical inertness and relative abundance also make it an ideal and cost-effective material for this critical role in deep drilling operations worldwide.

279. (C) A young, rapidly subsiding basin filled with uniform, uncemented sand.
A young, rapidly subsiding basin filled with uniform, uncemented sand is the least likely of these settings to host a significant mineral deposit. Such environments lack the necessary geological maturity, structural traps, or concentrated mineralizing fluids found in ancient subduction zones, stable cratons, or rift valleys. While they may accumulate some sediment, they do not provide the diverse and sustained geological processes required to concentrate minerals into

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temperatures and pressures during formation, and the effects of later tectonic events. This information is essential for understanding the origin of the deposit and for designing effective mineral processing and metallurgical extraction techniques that can efficiently recover the valuable metals from the ore.

265. (A) Both A and R are true and R is the correct explanation of A.
Bombay High is India's most important offshore oilfield. The assertion is correct. The reason accurately explains that the petroleum is trapped in a large, dome-like anticline structure within Miocene limestone reservoirs. This structural configuration and reservoir type are characteristic of the Mumbai offshore region's petroleum system. The successful identification and development of this field have been foundational to India's domestic energy production and the growth of its offshore oil and gas industry.

266. (A) In the manufacturing of stainless steel and other alloys.
Tungsten's most important industrial use is in the manufacturing of various alloys, particularly those used for cutting tools, drill bits, and high-strength steels. It imparts extreme hardness and exceptional heat resistance to these materials. While also used in filaments and specialized chemicals, its role in metallurgy is its primary economic driver. Tungsten is essential for modern manufacturing, construction, and high-performance engineering sectors due to its unique and indispensable physical properties and durability.

267. (D) Jharkhand
The Jharia coalfield is located in the state of Jharkhand and is critically important as India's primary source of prime coking coal. Coking coal is essential for the production of steel, making this coalfield a vital asset for the national economy and industrial growth. The Jharia region has a long history of intensive mining operations and hosts some of the country's most significant coal reserves within the Gondwana sedimentary sequences found in eastern India.

268. (B) P-4, Q-3, R-2, S-1
Singhbhum is a major source of copper and uranium, while Nellore is famous for mica. Panna is India's primary diamond-producing region, and Neyveli is known for its large-scale lignite deposits. Matching these regions with their primary mineral products illustrates the diverse and geographically distinct distribution of mineral resources across India. Each of these regions plays a critical role in supporting different sectors of the national economy, from energy and construction to luxury gemstones.

269. (B) The temperature range where oil is generated from kerogen source rock.
The 'oil window' refers to the specific range of temperatures, typically between sixty and one hundred and twenty degrees Celsius, where organic matter in source rocks is thermally converted into liquid crude oil. Below this range, the matter is immature; above it, oil is broken down into gas. Understanding this thermal maturation window is essential for petroleum geologists to identify the depth and location where extractable oil accumulations are likely to have formed.

270. (B) A manganese ore layer within a metamorphosed sedimentary sequence.
A manganese ore layer within a metamorphosed sedimentary sequence is a classic example of a syngenetic deposit. In this case, the manganese was originally deposited as a sedimentary layer at the same time as the surrounding sediments, and both were subsequently metamorphosed together. This is distinct from epigenetic deposits, such as quartz veins or skarns, which were introduced into pre-existing rocks by later fluids or intrusions long after the host rocks had already formed.

271. (B) Its properties as an excellent electrical and thermal insulator.
Mica's exceptional value in the electronics and electrical industries stems from its properties as an excellent electrical and thermal insulator. It possesses high dielectric strength and can withstand extreme temperatures without losing its insulating capabilities. Additionally, its ability to be split into very thin, flexible sheets makes it ideal for use in capacitors, heating elements, and as a substrate in various high-performance electronic components and specialized high-tech aerospace industrial applications.

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17. Which of the following is considered a 'pathfinder element' for many gold (Au) deposits?
(A) Iron (Fe)
(B) Arsenic (As)
(C) Silicon (Si)
(D) Aluminum (Al)

18. Which statement regarding sampling techniques for geochemical exploration is incorrect?
(A) Water sampling is only useful for detecting physical sediments.
(B) Soil sampling is effective for identifying secondary dispersion patterns.
(C) Stream sediment sampling provides a composite upstream sample.
(D) Rock chip sampling is used to analyze primary dispersion halos.

19. Consider the following statements:
Statement I : Epigenetic diffusion involves the introduction of elements into the host rock after the rock was formed.
Statement II : Syngenetic diffusion involves the dispersion of elements that is contemporaneous with the formation of the host rock.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

20. What is the fundamental principle of the electrical resistivity method in mineral exploration?
(A) Variations in rock densities alter the local gravitational field.
(B) Mineral magnetic susceptibility causes variations in the magnetic field.
(C) Sound wave speed changes as waves pass through different rock layers.
(D) Materials offer varying opposition to the flow of an electric current.

21. The term 'haulage' in the context of mining refers to:
(A) The vertical hoisting of personnel and materials in a shaft.
(B) The process of breaking rock using specific explosives.
(C) Horizontal transport of ore and waste to the surface or shaft.
(D) The process of supporting the roof of an underground excavation.

22. In contrast to rotary drilling, what is the characteristic action of percussion drilling?
(A) It uses a grinding action to abrade the rock.
(B) It uses a high-pressure water jet to cut through the rock.
(C) It melts the rock using a specialized thermal lance.
(D) It employs a rapid succession of blows to hammer the rock.

23. Which of the following statements correctly describes alluvial mining?
(A) It is a method of underground mining used for deep deposits.
(B) It involves creating a large open pit to extract hard rock.
(C) It extracts minerals from unconsolidated sand and gravel in riverbeds.
(D) It is a specialized technique for mining deep coal seams.

24. A mine is extracting a very large, low-grade, disseminated copper deposit located near the surface. Which mining method is most likely to be used?
(A) Room and pillar stoping
(B) Cut and fill stoping
(C) Longwall coal mining
(D) Open-cast mining

25. Consider the following statements:
Statement I : Stoping is the process of excavating the ore from an underground deposit.
Statement II : A 'stope' is the waste material left behind after the ore is extracted.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

26. All of the following are types of stoping methods used in underground mining EXCEPT:
(A) Cut-and-fill stoping
(B) Overburden stripping
(C) Shrinkage stoping
(D) Room and pillar stoping

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economically viable ore bodies for future mining and resource extraction.

280. (C) Panchpatmali, Odisha
The National Aluminium Company operates a major bauxite mine at the Panchpatmali plateau in the Koraput district of Odisha. This deposit is one of the largest and highest-quality bauxite sources in the world. The mine supplies bauxite to NALCO's refinery and smelter, making it a cornerstone of India's aluminum industry. The residual deposits at Panchpatmali were formed through intense weathering of khondalite rocks and are critical for the state's and nation's industrial economy.

281. (C) A cooling igneous intrusion
The heat source for the formation of most hydrothermal ore deposits is typically a cooling igneous intrusion. These magma bodies provide the thermal energy needed to drive the circulation of aqueous fluids through the Earth's crust. As the fluids circulate, they leach metals from both the intrusion and the surrounding country rock, eventually depositing them in fractures or other openings to form ore bodies. This magmatic heat is fundamental to the genesis of many metallic mineral deposits.

282. (A) Anthracite, Bituminous, Lignite, Peat
The correct decreasing order of coal rank is anthracite, followed by bituminous, then lignite, and finally peat. Rank represents the degree of coalification or thermal maturity reached by the organic matter. Anthracite has the highest carbon content and calorific value, while peat is the least mature form with the highest moisture content and lowest carbon percentage. This progression reflects the chemical and physical changes that occur as coal matures under heat and pressure over geological time.

283. (D) 1, 2, and 3
Mining in India is governed by the Mines and Minerals Act, strategic minerals are vital for national defense, and mineral concession rules provide the framework for granting mining rights. All three statements correctly describe the principal legislation, concepts, and regulatory structures within the Indian mineral sector. Together, they ensure that mineral resources are managed systematically, supporting both national security and industrial development while providing a formal legal process for exploration and extraction activities nationwide.

284. (B) Iron Ore
The Dalli-Rajhara mines in Chhattisgarh are a critical captive source of high-grade iron ore for the Bhilai Steel Plant. These mines provide the essential raw material needed for the plant's massive steel production operations. The ore, primarily hematite, is mined and transported directly to the facility. This close integration of mining and metallurgy is a key feature of India's industrial landscape, ensuring a steady supply of iron for one of the country's most important steelmaking centers.

285. (A) Both A and R are true and R is the correct explanation of A.
Studying ore textures under a microscope is essential for designing effective mineral processing and metallurgical extraction techniques. The assertion correctly identifies this practical application. The reason accurately explains that textures reveal the size, shape, and intergrowth of minerals, which dictates how the ore must be crushed and separated to recover the valuable components. This detailed understanding of the ore's internal architecture is critical for ensuring the economic efficiency and success of industrial mining and refining operations.

286. (B) A deposit concentrated in-situ by weathering and removal of minerals.
A residual mineral deposit is one that is concentrated in-situ through the intense chemical weathering of a parent rock and the removal of soluble constituents. This process leaves behind a residuum of insoluble ore minerals, such as bauxite or lateritic iron ore. This mechanism is distinct from transportation-based processes like placers or direct crystallization from magma. Residual deposits typically form in humid tropical environments where sustained weathering can lead to the significant enrichment of aluminum, iron, or nickel oxides.

287. (D) Bauxite
Bauxite is the primary and most important ore for aluminum. It is a residual rock formed through the intense chemical weathering of aluminous

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257. (B) Uranium and Copper
In India, occurrences of molybdenum are often found in close association with the ores of uranium and copper. For example, in the Singhbhum Shear Zone, molybdenum minerals have been identified alongside uranium and copper mineralization. Molybdenum is a valuable alloying element used in high-strength steels. Identifying these geological associations is important for mineral exploration, as it allows geologists to prospect for multiple valuable metals within the same mineralized systems and geological provinces.

258. (A) A country rich in mineral resources always has a highly developed economy.
Being rich in mineral resources does not always lead to a highly developed economy; this is often referred to as the resource curse" where mismanagement or lack of diversification hinders growth. However, mineral policies, the importance of strategic minerals, and the factors determining a deposit's value are all correct principles of mineral economics. Developing a national economy requires not just the presence of resources but also their efficient, sustainable, and transparent management.

259. (B) A maceral is an individual organic particle, while a microlithotype is a characteristic association of macerals.
Macerals are the individual microscopic organic constituents of coal, analogous to minerals in a rock. A microlithotype is a characteristic association of these macerals occurring in bands at least 50 micrometers wide. Studying both is essential for understanding coal petrology; macerals determine the chemical behavior of the coal, while microlithotypes provide information about the depositional environment and plant communities that formed the original peat, which eventually became the coal deposit.

260. (B) Sulphides (e.g., chalcocite, covellite)
Supergene enrichment is primarily responsible for creating a secondary zone of enriched sulphide minerals, such as chalcocite and covellite. This process occurs below the water table when metal-rich acidic waters, leached from the upper oxidized zone, react with primary minerals like chalcopyrite. This re-precipitation concentrates metals like copper into a much richer ore zone than the original primary mineralization, significantly increasing the economic value and feasibility of the mineral deposit for mining.

261. (B) Bauxite in Odisha and Andhra Pradesh
The rocks of the Khondalite Group in the Eastern Ghats serve as the primary parent material for the major bauxite deposits in Odisha and Andhra Pradesh. Intense chemical weathering and lateritization of these aluminous rocks in tropical climates lead to the residual concentration of aluminum oxides. These deposits form some of the world's largest bauxite reserves and are the foundation for India's massive aluminum industry, supporting both domestic production and significant international exports.

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262. (D) 1, 2, and 3
Galena and sphalerite are the primary ore minerals for lead and zinc, typically occurring together in hydrothermal and replacement deposits. Major Indian sources are located in the Zawar and Rampura-Agucha belts of Rajasthan. All three statements correctly describe the mineralogy, typical geological occurrences, and primary geographical locations of lead and zinc resources in India. These minerals and regions are critical for the nation's supply of base metals and industrial development.

263. (B) Difference in chemical composition and crystal structure.
The primary features used to distinguish between different asbestos minerals are their chemical composition and crystal structure. For example, chrysotile is a serpentine mineral with a sheet-like structure, while crocidolite is an amphibole with a double-chain structure. These fundamental differences result in varying physical properties such as fiber strength, heat resistance, and flexibility. Identifying these characteristics is essential for both geological classification and for understanding the health and safety implications of these fibrous minerals.

264. (B) To understand the history of ore formation and later deformation.
The main objective of studying ore textures and structures is to reconstruct the history of ore formation and any subsequent geological deformation. These features provide clues about the sequence of mineral crystallization, the

controlled lighting conditions, even when they are finely disseminated in rock. This method is a standard tool for geologists during field surveys and mining operations to quickly locate and assess tungsten mineralization in various types of hydrothermal and skarn mineral deposits.

295. (C) Gravity settling of early-formed heavy crystals
Gravity settling of early-formed heavy crystals, such as chromite or magnetite, is a fundamental process of magmatic concentration. This occurs within a cooling magma chamber where dense minerals sink through the less dense melt and accumulate at the base, forming concentrated ore layers. In contrast, hydrothermal veins, evaporites, and weathering-based deposits are formed through completely different geological mechanisms involving aqueous fluids, solar evaporation, or chemical alteration at the surface. Understanding these genetic processes is essential for correctly identifying and exploring for different types of mineral resources.

296. (C) Tipam Sandstones (Tertiary)
The Digboi field in Assam, India's oldest producing oilfield, primarily produces petroleum from the Tipam Sandstones of the Tertiary age. These sedimentary rocks serve as the reservoir for the hydrocarbons generated within the basin. The successful identification and production from these formations in the late nineteenth century marked the beginning of the Indian oil industry. The Tipam Sandstones continue to be important targets for oil and gas exploration in the region, reflecting the geological significance of Tertiary sequences in Assam.

297. (B) The way in which mineral deposits are formed.
Ore genesis is the study of the various geological processes and environmental conditions that lead to the formation of mineral deposits. This field explores how metals are leached, transported, and concentrated into economically viable ore bodies through magmatic, hydrothermal, sedimentary, or metamorphic mechanisms. Understanding ore genesis is fundamental for geologists, as it provides the theoretical framework needed to identify potential mineral occurrences and to develop effective strategies for mineral exploration and resource management within the Earth's crust.

298. (D) All varieties of coal have the same carbon content and calorific value.
Coal is indeed a combustible sedimentary rock composed of macerals like vitrinite, and its formation involves coalification from peat. However, the statement that all varieties have the same carbon content and calorific value is incorrect. As coal rank increases from peat to anthracite, the carbon percentage and energy density significantly rise while moisture and volatiles decrease. This variation in composition is fundamental to coal geology and determines the quality and industrial value of different coal deposits for energy production and metallurgy.

299. (B) Gujarat
The Kakrapar Atomic Power Station is located in the Tapi district of Gujarat. It is a major nuclear power facility in western India, utilizing pressurized heavy water reactors to generate electricity for the regional grid. The station is an important part of India's nuclear energy program, providing a reliable and large-scale source of power for the state's industrial and domestic sectors. Its ongoing expansion reflects the country's commitment to increasing the role of nuclear energy in its overall power generation mix and energy security.

300. (B) 2, 3, 1
A typical weathered sulphide deposit displays a vertical sequence starting with the gossan, or leached cap, at the surface. Below this lies the enriched sulphide zone, also known as the supergene zone, where metals leached from above have re-precipitated. Finally, the primary ore or hypogene zone is found at depth, remaining unaffected by surface weathering. This sequence, ordered from the surface downwards, represents the characteristic architectural profile resulting from the weathering of metallic mineral deposits in diverse geological and environmental settings.

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CHAPTER 09

Mineral Exploration, Mining, Mineral dressing and Hydrogeology

1. In the context of mineral exploration, what is the primary objective of creating an exploratory grid?
(A) To initiate the process of mineral dressing and processing.
(B) To provide a systematic framework for geological mapping and sampling.
(C) To establish the final legal boundaries of the mine lease area.
(D) To serve as a primary haulage route for transporting ore.

2. Which of the following is a direct method of subsurface geological exploration that provides a physical, cylindrical sample of the rock?
(A) Core sampling
(B) Well logging
(C) Trenching
(D) Placer sampling

3. Identify the correct statement regarding well logging.
(A) It is a method of physically extracting large rock samples from a borehole.
(B) It is exclusively used for determining the magnetic properties of the ore.
(C) It involves lowering instruments into a borehole to record physical properties.
(D) It is a surface exploration technique that does not require any drilling.

4. A geologist suspects the presence of a shallow, flat-lying ore body. To expose a continuous cross-section of the near-surface geology over a considerable length, which method would be most appropriate?
(A) Sinking a deep shaft
(B) Creating a series of isolated pits
(C) Conducting a regional gravity survey
(D) Digging a long, narrow trench

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5. Consider the following statements:
Statement I : Channel sampling involves cutting a continuous channel of uniform width and depth across an exposure to collect a sample.
Statement II : Grab sampling, where specimens are taken at random, is generally more representative of the entire ore body than channel sampling.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

6. All of the following are essential components of calculating ore reserves EXCEPT:
(A) The volume or tonnage of the ore body.
(B) The market price of the final refined metal.
(C) The average grade or quality of the ore.
(D) The geological confidence in the mineralization.

7. Which of the following statements about the UNF (United Nations Framework) classification of reserves is incorrect?
(A) It is a three-dimensional system based on economic and geological factors.
(B) The E-axis represents the economic and social viability of the project.
(C) The G-axis represents the geological knowledge and confidence.
(D) It is primarily designed for classifying rock types rather than resources.

8. Match List I (Exploration Technique) with List II (Primary Objective).
List I: (Exploration Technique)
P. Pitting and Trenching
Q. Core Drilling
R. Well Logging
S. Placer Sampling
List II: (Primary Objective)

1. Obtaining continuous physical record of subsurface rock properties
2. Evaluating unconsolidated surficial deposits like gold in riverbeds
3. Exposing and sampling near-surface mineralization
4. Obtaining cylindrical rock samples from depth for analysis

(A) P-3, Q-4, R-1, S-2
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-1, R-4, S-2
(D) P-4, Q-3, R-2, S-1

9. The term 'assaying' in mineral exploration and mining is best defined as:
(A) The process of calculating the total volume of an ore deposit.
(B) The physical separation of minerals from waste rock.
(C) The chemical analysis of a sample to determine mineral concentration.
(D) The legal process of acquiring mineral rights.

10. What is a key principle of the seismic method in mineral exploration?
(A) It measures shock wave travel times through reflection and refraction.
(B) It measures variations in the Earth's gravitational field via density.
(C) It maps rock conductivities by passing an electric current into the ground.
(D) It detects anomalies in the Earth's magnetic field via specific minerals.

11. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : Pathfinder elements are often used in geochemical exploration.
Reason (R) : Pathfinder elements are more mobile or more easily detected than the main ore element and can lead geologists to a nearby deposit.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(A) A is true but R is false.
(D) A is false but R is true.

12. In geochemical exploration, what does 'primary dispersion' refer to?
(A) The dispersion of elements into soil and drainage systems by weathering.
(B) The dispersion of elements occurring during host rock or deposit formation.
(C) The study of plant chemistry used to indicate specific mineralization.
(D) The artificial introduction of tracers into a groundwater system.

13. Identify the correct pair of a geophysical method and the primary physical property it measures.
(A) Gravity method - Electrical resistivity
(B) Magnetic method - Rock density
(C) Electrical method - Electrical conductivity/ resistivity
(D) Seismic method - Magnetic susceptibility

14. Consider the following statements about geochemical exploration:
1. The geochemical cycle describes the migration of chemical elements in the Earth's crust.
2. The mobility of an element is independent of environmental factors like pH and Eh.
3. Secondary dispersion refers to the redistribution of elements in the surficial environment by processes like weathering.

Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

15. The presence of specific plant species, or 'indicator plants', that thrive in metal-rich soils is the basis for which exploration technique?
(A) Geobotanical exploration
(B) Geochemical exploration
(C) Gravity method
(D) Syngenetic diffusion study

16. If a buried ore body is significantly denser than the surrounding host rocks, which geophysical method would be most effective in detecting its presence?
(A) Magnetic method
(B) Gravity method
(C) Electrical resistivity method
(D) Geobotanical method

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parent rocks in tropical and subtropical regions. Bauxite consists mainly of aluminum hydroxide minerals along with iron and titanium oxides. While other minerals like corundum or kaolinite contain aluminum, bauxite is the only one used for commercial large-scale extraction due to its high aluminum content and the relative ease of processing it through the electrolytic smelting process.

288. (A) P-3, Q-2, R-4, S-1
Paragenesis describes the temporal sequence of mineral formation, while zoning refers to the spatial distribution pattern of minerals. Syngenetic deposits form at the same time as their host rock, and epigenetic deposits form after the host rock. Correctly matching these terms to their descriptions is fundamental for understanding ore genesis and the geological history of mineral deposits. These concepts provide geologists with a structured framework for identifying, classifying, and exploring for various types of mineral resources found in nature.

289. (A) The type of primary sulphide mineral that was originally present.
Boxwork structures in a gossan are often indicators of the specific type of primary sulphide mineral that was originally present before it was leached away. Different minerals, such as chalcopyrite, sphalerite, or galena, leave behind characteristic patterns of iron oxide ridges or cavities as they oxidize and dissolve. Geologists use these boxwork" patterns as valuable clues to identify the metallic potential of a weathered mineral deposit and to help guide further underground exploration and drilling efforts.

290. (B) To develop mineral resources in a sustainable and scientific manner.
A fundamental principle of the National Mineral Policy is to ensure that mineral resources are developed in a sustainable, scientific, and systematic manner. The policy aims to balance the need for mineral extraction to support economic growth with the necessity of environmental conservation and social responsibility. It encourages modern exploration techniques, efficient resource utilization, and private sector participation while maintaining government oversight to ensure that the nation's mineral wealth is managed for long-term benefit and ecological stability.

291. (D) Gypsum
Pitchblende, monazite, and beryl are all atomic minerals because they contain elements like uranium, thorium, and beryllium, which are used in nuclear energy and related high-tech sectors. Gypsum, however, is a non-metallic industrial mineral primarily used in the cement and fertilizer industries and has no radioactive or nuclear applications. This distinction is important for understanding the different classifications of minerals based on their chemical properties and their specific roles in energy production and industrial manufacturing processes.

292. (A) Both Statement I and Statement II are true.
A structural trap is indeed formed by the deformation of rock layers, such as folding into anticlines or faulting, as stated in the first sentence. Furthermore, the second statement is true as it correctly identifies that stratigraphic traps are created by changes in rock type or lithology, such as pinch-outs or unconformities. Both types of traps are essential for confining hydrocarbons underground, and understanding their different origins is a fundamental aspect of petroleum geology and successful oil and gas exploration.

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293. (C) Mica and Coal
The Hazaribagh region in Jharkhand is historically and geologically famous for its significant deposits of mica and coal. The region was once part of the world-renowned Bihar mica belt, producing high-quality muscovite mica from pegmatites. Additionally, the surrounding basins host important coal reserves within the Gondwana sedimentary sequences. These two resources have been major drivers of the local economy and have contributed significantly to India's industrial and energy sectors for over a century of production.

294. (C) Its bright blue-white fluorescence under ultraviolet light
Scheelite, an important ore of tungsten, is frequently prospected for using its property of bright blue-white fluorescence under ultraviolet light. This unique characteristic makes it easy to identify scheelite crystals in the dark or under

27. Which of the following statements regarding coal mining methods is incorrect?
(A) Longwall mining is an underground method using a shearing machine.
(B) Room and pillar mining leaves pillars of coal to support the roof.
(C) Open-cast or strip mining is used when coal seams are near surface.
(D) Coal is exclusively mined using alluvial gold mining techniques.

28. Match List I (Mining Term) with List II (Description).
List I: (Mining Term)
P. Winding
Q. Stope
R. Haulage
S. Alluvial Mining
List II: (Description)
1. Excavation of ore from placer deposits
2. The void created by the extraction of ore in an underground mine
3. Vertical hoisting of men, materials, and ore in a shaft
4. Horizontal transportation of mined material
(A) P-4, Q-1, R-3, S-2
(B) P-3, Q-2, R-4, S-1
(C) P-3, Q-4, R-1, S-2
(D) P-1, Q-2, R-4, S-3

29. What is the primary function of 'winding' equipment in an underground mine?
(A) To ventilate the underground workings.
(B) To pump water out of the mine.
(C) To transport materials and personnel vertically through a shaft.
(D) To transport ore horizontally along tunnels.

30. Rotary drilling is generally more efficient than percussion drilling in which type of rock formation?
(A) Very hard, brittle crystalline rocks.
(B) Soft, unconsolidated formations like clay and shale.
(C) Highly fractured and broken ground.
(D) Glacial till containing large boulders.

31. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : Mineral dressing, or beneficiation, is a crucial step between mining and extractive metallurgy.
Reason (R) : It aims to increase the concentration of valuable minerals by physically separating them from the waste rock (gangue).
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

32. The froth flotation technique is most widely and effectively used for the concentration of which type of ores?
(A) Oxide ores
(B) Sulphide ores
(C) Carbonate ores
(D) Silicate ores

33. Identify the correct statement about crushers used in mineral dressing.
(A) Grinding mills are used for primary crushing of run-of-mine ore.
(B) Jaw crushers and gyratory crushers are typically used as primary crushers.
(C) Secondary crushers are designed to produce a very fine product.
(D) Crushing is a process that uses chemical reagents to break ore.

34. Consider the following physical properties of minerals:
1. Hardness
2. Specific Gravity
3. Magnetic Susceptibility
Which of these properties are commonly utilized in mineral dressing for physical separation?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

35. The purpose of industrial screening in a mineral processing plant is to:
(A) Separate minerals based on their magnetic properties.
(B) Increase the grade of the ore using chemical reagents.
(C) Separate particles into different size fractions.

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55. The calculation of ore reserves requires an understanding of the deposit's geometry and grade, which are primarily determined through:
(A) Regional meteorological data.
(B) Satellite imagery of vegetation cover.
(C) Historical records of seismic activity.
(D) Analysis of drilling, sampling, and assaying data.

56. Underground mining sampling differs from surface sampling primarily because:
(A) It is conducted on vertical or inclined stope faces.
(B) The samples are inherently less valuable.
(C) It does not require any chemical analysis.
(D) The samples are always unconsolidated material.

57. According to the UNF Classification, what distinguishes a 'mineral resource' from a 'mineral reserve'?
(A) The geological confidence in its existence.
(B) The depth at which the mineral is found.
(C) The consideration of viability and technical factors.
(D) The type of commodity (e.g., metal vs. industrial).

58. Which of the following is not a direct method of geological exploration?
(A) Drilling
(B) Trenching
(C) Gravity survey
(D) Pitting

59. A geologist is evaluating a placer gold deposit in a river valley. Which sampling method is specifically designed for this type of deposit?
(A) Core sampling
(B) Placer sampling
(C) Channel sampling
(D) Underground mining sampling

60. The process of evaluating a deposit through techniques like core sampling and well logging aims to:
(A) Reduce geological uncertainty associated with the deposit.
(B) Immediately begin the mineral dressing process.
(C) Secure environmental clearances for the mine.
(D) Design the haulage and winding system.

61. What is a key limitation of the gravity method in mineral exploration?
(A) It can only be used to find magnetic minerals.
(B) It cannot penetrate below the topsoil layer.
(C) It requires corrections for elevation and topography.
(D) It is only effective in underwater exploration.

62. The concept of 'mobility of elements' in the geochemical cycle is crucial because:
(A) It controls travel distance from source element dispersion.
(B) It determines the magnetic properties of an element.
(C) It dictates the method of drilling required for exploration.
(D) It is only relevant for elements in a solid state.

63. Which geophysical method would be most suitable for mapping a buried, highly conductive graphite body?
(A) Gravity method
(B) Magnetic method
(C) Electrical method
(D) Seismic refraction

64. 'Syngenetic' and 'epigenetic' are terms used to describe the timing of what process relative to the host rock?
(A) The diffusion and dispersion of elements.
(B) The mining of the ore.
(C) The artificial recharge of groundwater.
(D) The application of froth flotation.

65. Consider the following statements:
Statement I : A geochemical 'background' value represents the normal, typical concentration of an element in unmineralized material in a given area.
Statement II : A geochemical 'anomaly' is a deviation from this background value that may indicate mineralization.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

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(B) Natural seepage from rivers and lakes
(C) Injection wells
(D) Check dams that induce recharge

47. Which of the following statements about watershed management is incorrect?
(A) It involves management of resources within watershed boundaries.
(B) It aims to conserve soil and water for sustainable development.
(C) It focuses exclusively on surface water, ignoring groundwater.
(D) It integrates practices like afforestation and check dams.

48. Match List I (Hydrogeological Term) with List II (Definition).
List I: (Hydrogeological Term)
P. Aquifer
Q. Aquiclude
R. Water Table
S. Darcy's Law
List II: (Definition)
1. Upper surface of the zone of saturation
2. Impermeable formation that neither stores nor transmits water
3. Equation describing groundwater flow rate
4. Permeable formation that stores and transmits water
(A) P-1, Q-3, R-2, S-4
(B) P-4, Q-2, R-1, S-3
(C) P-4, Q-1, R-2, S-3
(D) P-2, Q-4, R-1, S-3

49. What is the most significant hydrological property of a rock that determines its ability to be an aquifer?
(A) Its color and texture.
(B) Its age and origin.
(C) Its permeability and porosity.
(D) Its magnetic susceptibility.

50. The concept of water harvesting primarily involves:
(A) The exploration for deep, confined aquifers.
(B) The desalination of seawater to produce fresh water.
(C) The collection and storage of rainwater for later use.
(D) The treatment of industrial wastewater.

51. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : An unconfined aquifer is more susceptible to surface contamination than a confined aquifer.
Reason (R) : An unconfined aquifer is directly connected to the surface and is not protected by an overlying impermeable layer.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

52. The term commercial grade" when referring to an ore deposit implies that:
(A) The ore contains 100% pure metal.
(B) The deposit is large enough to be seen from space.
(C) The ore can be mined and processed at a profit.
(D) The ore is owned and operated by a government entity.

53. Which drilling technology is used for exploration purposes?
(A) Auger drilling
(B) Sonic drilling
(C) Percussion and Rotary drilling
(D) Laser drilling

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54. Consider the following statements about ore reserve classification:
1. Classification of reserves helps in mine planning and financial evaluation.
2. The term 'reserve' implies that the mineral is not only discovered but also economically and technically mineable.
3. The UNF classification is a globally recognized system for classifying mineral resources and reserves.
Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

3. These methods rely on detecting contrasts in the physical properties of rocks.

Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

75. What is the main cause of a gravity anomaly detected during a geophysical survey?
(A) A lateral variation in the magnetic susceptibility of rocks.
(B) A lateral variation in the density of subsurface rocks.
(C) A lateral variation in the electrical conductivity of rocks.
(D) A lateral variation in the regional vegetation cover.

76. The term 'mining terminology' refers to:
(A) The specific languages spoken by miners.
(B) Vocabulary describing operations, equipment, and features.
(C) The legal jargon used in mining contracts.
(D) The chemical formulas of minerals.

77. What is the fundamental difference between open-cast mining and underground mining?
(A) Open-cast mining is for coal; underground is for metals.
(B) Open-cast uses percussion; underground uses rotary drilling.
(C) Open-cast is traditional; underground mining is modern.
(D) Open-cast is from surface; underground uses shafts and tunnels.

78. Which of the following is a key characteristic of the longwall method of coal mining?
(A) High coal recovery achieved by roof collapse.
(B) It leaves many coal pillars to support the roof.
(C) It is a surface mining method.
(D) It is primarily used for mining small coal seams.

79. A situation where weak ground conditions in an underground mine require the excavated area to be immediately filled with waste material to provide support would favor which stoping method?
(A) Open stoping
(B) Cut-and-fill stoping
(C) Shrinkage stoping
(D) Room and pillar stoping

80. Consider the following extraction types:
I. Underground stoping methods
II. Open-cast mining
III. Alluvial mining

Arrange the drilling methods and mining types in a logical sequence of development from surface to deep extraction.
(A) I, II, III
(B) III, I, II
(C) II, III, I
(D) III, II, I

81. Consider the following statements:
Statement I : Percussion drilling breaks rock by hammering and chipping.
Statement II : Rotary drilling breaks rock by grinding and cutting with a rotating bit.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

82. All of the following are mining methods EXCEPT:
(A) Alluvial mining
(B) Open-cast mining
(C) Stoping methods
(D) In-situ leaching

83. Which statement regarding the classification of mining methods is incorrect?
(A) Methods are classified into surface and underground mining.
(B) Choice depends on depth, geometry, and rock strength.
(C) All underground mining methods are classified as stoping methods.
(D) Coal mining has specific methods like longwall and room-and-pillar.

84. In room and pillar mining, what is the primary function of the pillars?
(A) To be sold as high-quality blocks of ore.
(B) To mark the boundaries of the mining lease.
(C) To serve as permanent roof support for workings.

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66. All of the following are typically sampled in geochemical exploration EXCEPT:
(A) Rock
(B) Soil and Stream Sediments
(C) Plant material (biogeochemistry)
(D) The Earth's magnetic field

67. Which of the following statements about the magnetic method is incorrect?
(A) It measures variations in the density of subsurface rocks.
(B) It is effective for exploring for iron ores like magnetite.
(C) Surveys can be conducted on the ground or from the air.
(D) The data needs to be corrected for diurnal variations.

68. Match List I (Geochemical Concept) with List II (Description).
List I: (Geochemical Concept)
P. Primary Dispersion
Q. Secondary Dispersion
R. Pathfinder Element
S. Geobotanical Anomaly
List II: (Description)
1. A mobile, easily detected element associated with the main ore element
2. Abnormal vegetation patterns caused by soil chemistry
3. Dispersion of elements into the weathering environment
4. Dispersion of elements during ore and rock formation
(A) P-1, Q-2, R-3, S-4
(B) P-4, Q-3, R-2, S-1
(C) P-4, Q-3, R-1, S-2
(D) P-3, Q-4, R-1, S-2

69. The occurrence of trace elements in rocks and soils is studied in geochemical exploration because:
(A) They are the primary components of all ore deposits.
(B) They are the only elements that can be detected by geophysical methods.
(C) Their distribution patterns can point towards hidden mineralization.
(D) They determine the hydrological properties of the rock.

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70. Which of the following is a primary objective of classifying geophysical methods?
(A) To organize them based on the physical property measured.
(B) To rank them in order of their cost.
(C) To determine suitability for ancient mining.
(D) To classify them based on the country of invention.

71. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : The seismic method is widely used in the petroleum industry for mapping subsurface geological structures.
Reason (R) : It can provide high-resolution images of sedimentary layers, folds, and faults that can act as traps for oil and gas.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

72. The choice of sampling technique in geochemical exploration, such as soil, stream sediment, or rock sampling, is most dependent on:
(A) The type of dispersion pattern (primary or secondary).
(B) The mining method that will eventually be used.
(C) The company conducting the exploration.
(D) The magnetic properties of the ore.

73. 'Epigenetic diffusion' of elements implies that the elements:
(A) Were present before the host rock was formed.
(B) Formed at the exact same time as the host rock.
(C) Were introduced into the host rock after its formation.
(D) Are completely immobile and do not diffuse.

74. Consider the following statements about geophysical exploration:
1. It is a direct method that always confirms the presence of ore.
2. Electrical, magnetic, gravity, and seismic are the four main classes of methods.

116. Consider the following statements:
Statement I : The seismic reflection method is based on measuring travel times of waves bounced off subsurface interfaces.
Statement II : The gravity method is based on measuring variations in electrical resistivity.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

117. Secondary dispersion halos, which are often the target of soil and stream sediment sampling, are formed by:
(A) The crystallization of minerals from a magma.
(B) The introduction of elements by hydrothermal fluids.
(C) The direct measurement of rock density.
(D) Weathering and redistribution of a primary ore body.

118. Which of these geophysical methods is passive, meaning it measures a natural field of the Earth?
(A) Gravity method
(B) Seismic reflection method
(C) Electrical resistivity method
(D) Induced polarization method

119. A geobotanical survey reveals an area of stunted tree growth and a species of copper moss" that is not found elsewhere. This is an example of:
(A) A geophysical anomaly.
(B) A sampling error in a geochemical survey.
(C) A geobotanical anomaly indicating potential mineralization.
(D) A primary dispersion pattern.

120. Consider the following processes:
I. Formation of a secondary dispersion halo in soil.
II. Formation of a primary dispersion halo in rock around an intrusion.
III. Weathering of the outcrop of the ore body.
Arrange the geochemical dispersion processes in a logical order from source to the surficial environment.
(A) I, II, III
(B) II, I, III
(C) II, III, I
(D) III, II, I

121. The mobility of an element in the near-surface geochemical environment is LEAST affected by which of the following?
(A) The pH of the water.
(B) The Eh of the environment.
(C) The presence of organic matter.
(D) The magnetic susceptibility of the element.

122. In the context of drilling, what is the main advantage of rotary drilling over percussion drilling for deep holes in sedimentary basins?
(A) It is less expensive for shallow depths.
(B) Faster and smoother deep penetration in softer rocks.
(C) It does not require any drilling fluid.
(D) It produces larger rock chips for analysis.

123. The term 'stoping' is exclusively used in which type of mining?
(A) Alluvial mining
(B) Open-cast mining
(C) Underground hard rock mining
(D) Coal strip mining

124. Which of the following is a key characteristic of alluvial mining?
(A) It targets deep, high-grade vein deposits.
(B) It involves the creation of permanent underground tunnels.
(C) It requires extensive use of explosives.
(D) It processes unconsolidated sediments like sand and gravel.

125. Consider the following statements:
Statement I : Haulage refers to the vertical transport of ore in a mine shaft.
Statement II : Winding refers to the horizontal transport of ore in tunnels.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

126. Which mining method is characterized by high production rates and low operating costs, making it suitable for large, near-surface deposits?
(A) Cut-and-fill stoping
(B) Open-cast mining
(C) Shrinkage stoping
(D) Room and pillar stoping

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(D) To store waste rock generated during mining.

85. Which component of a mining operation is responsible for moving men and materials vertically between the surface and the underground levels?
(A) The haulage system
(B) The winding system
(C) The stoping system
(D) The drilling system

86. What is the primary purpose of mineral dressing?
(A) To analyze the chemical composition of the ore.
(B) To physically separate valuable minerals from gangue.
(C) To smelt the ore concentrate into pure metal.
(D) To explore for new mineral deposits.

87. Which piece of equipment is designed for fine grinding of ore, reducing it to a powder-like consistency?
(A) Jaw crusher
(B) Grinding mill (e.g., ball mill, rod mill)
(C) Gyratory crusher
(D) Industrial screen

88. The principle of magnetic separation relies on the difference in which property among minerals?
(A) Specific gravity
(B) Surface wettability
(C) Magnetic susceptibility
(D) Particle size

89. A mineral processing plant wants to separate magnetite (a strongly magnetic iron oxide) from quartz (non-magnetic). Which separation technique would be most appropriate?
(A) Froth flotation
(B) Gravity separation
(C) Magnetic separation
(D) Heavy medium separation

90. Consider the following statements:
Statement I : Froth flotation separates minerals based on their differing surface properties, specifically their wettability or hydrophobicity.
Statement II : It is a type of gravity separation method.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

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91. What is the role of a 'grinding mill' in mineral dressing?
(A) It performs initial breaking of large rocks.
(B) It sorts particles based on their size.
(C) It reduces crushed ore to fine particles to liberate minerals.
(D) It separates minerals using a dense liquid medium.

92. All of the following are physical properties of minerals utilized in mineral dressing EXCEPT:
(A) Properties utilized in gravity separation (density).
(B) Properties utilized in magnetic separation (magnetism).
(C) Properties utilized in froth flotation (surface properties).
(D) Radioactivity of the mineral.

93. Which statement about the historical Zawar Mines in Rajasthan is correct?
(A) It is a case study for watershed management.
(B) It shows ancient mining evidence for lead and zinc.
(C) It is the primary site for froth flotation research.
(D) It is a modern example of open-cast gold mining.

94. What is the difference between a primary and a secondary crusher?
(A) Primary is for hard rocks; secondary is for soft rocks.
(B) Primary is used underground; secondary is used in open-cast.
(C) Primary handles coarse ore; secondary reduces primary output.
(D) Primary uses magnetic force; secondary uses gravity.

95. Heavy medium separation is a process where particles are separated based on their:
(A) Ability to float in a liquid of intermediate density.

(B) Attraction to a high-intensity magnetic field.
(C) Affinity for air bubbles in a water slurry.
(D) Hardness and resistance to grinding.

96. The vast majority of water on Earth's surface is found in:
(A) Rivers and lakes
(B) Glaciers and ice caps
(C) Oceans
(D) Groundwater

97. The term 'subsurface water' encompasses all water that occurs:
(A) Only in deep, confined aquifers.
(B) Below the ground surface.
(C) In glaciers and ice sheets.
(D) In rivers and streams.

98. Match List I (Water Body) with List II (Description).
List I: (Water Body)
P. Groundwater in a phreatic aquifer
Q. A mountain lake
R. An ice cap
S. Connate water
List II: (Description)
1. Solid form of surface water
2. Subsurface water recharged by precipitation
3. A body of surface water
4. Subsurface water trapped during sediment deposition
(A) P-1, Q-3, R-2, S-4
(B) P-2, Q-3, R-1, S-4
(C) P-4, Q-1, R-2, S-3
(D) P-2, Q-4, R-1, S-3

99. A geological formation that is porous but has very low permeability, thus being unable to transmit water freely, is known as:
(A) An aquifer
(B) An aquitard
(C) A riverbed
(D) An open well

100. Which of the following is considered a biological characteristic of groundwater quality?
(A) The presence of dissolved solids.
(B) The water's temperature.
(C) The pH of the water.
(D) The presence of bacteria, such as coliforms.

101. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : Darcy's Law is applicable only for laminar flow conditions in porous media.
Reason (R) : At high velocities, groundwater flow becomes turbulent, and the linear relationship between flow velocity and hydraulic gradient described by Darcy's Law breaks down.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

102. What is a key objective of wetland management?
(A) To preserve ecological functions and biodiversity.
(B) To drain wetlands for agricultural conversion.
(C) To use wetlands for industrial waste disposal.
(D) To build concrete structures in wetland areas.

103. The 'concept of watershed management' implies an approach that:
(A) Treats the entire drainage area as a single unit.
(B) Focuses only on the main river channel.
(C) Is solely concerned with the construction of dams.
(D) Prioritizes groundwater extraction over conservation.

104. Consider the following regarding groundwater recharge:
1. Natural recharge occurs mainly from precipitation and seepage from surface water bodies.
2. Artificial recharge involves augmenting the natural replenishment of groundwater stores.
3. Building check dams across streams can be a method of artificial recharge.
Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

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105. An aquifer that is sandwiched between two impermeable layers (aquicludes) is known as:
(A) An unconfined aquifer
(B) A perched aquifer
(C) A confined aquifer
(D) A surface reservoir

106. In the evaluation of mineral deposits, 'well logging' primarily provides what kind of data?
(A) A log of electrical measurements.
(B) Records of in-situ physical properties of formations.
(C) A collection of rock chips brought to the surface.
(D) An assay report of the average deposit grade.

107. Which statement accurately describes the function of 'pits' in mineral exploration?
(A) They are large-scale excavations for production mining.
(B) They are deep, narrow boreholes drilled to obtain core.
(C) Shallow excavations used to expose and sample bedrock.
(D) They are part of the mineral dressing plant.

108. The main advantage of using core sampling over other drilling methods is that it:
(A) Is the cheapest and fastest drilling method.
(B) Provides an undisturbed sample preserving rock texture.
(C) Requires no water or drilling fluid.
(D) Can only be used for surface exploration.

109. Consider the following statements:
Statement I : The calculation of ore reserves is a static process that does not change over the life of a mine.
Statement II : Ore reserve estimates are dynamic and can change due to new exploration data, changes in mining costs, or fluctuations in commodity prices.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

110. Which is NOT a primary goal of geological exploration for commercial grade ore deposits?
(A) To determine the location and size of the deposit.
(B) To estimate the grade and tonnage of the ore.
(C) To understand geological setting and mineralization.
(D) To design the marketing strategy for refined metal.

111. What does the mode of occurrence of a commercial grade deposit refer to?
(A) The way in which the ore is mined.
(B) The market demand for the mineral.
(C) The method of mineral dressing used.
(D) The geological form and characteristics of the ore body.

112. The G-axis in the UNFC system for reserve classification represents the:
(A) Economic viability of the project.
(B) The level of geological knowledge and confidence.
(C) Feasibility of the mining and processing methods.
(D) Governmental approval status of the project.

113. Channel sampling is considered a superior method to random grab sampling because it:
(A) Is faster and requires less effort.
(B) Does not require any assaying.
(C) Provides a representative sample across the ore body.
(D) Can be done from a moving vehicle.

114. The term 'geochemical cycle' refers to the:
(A) Annual budget cycle for a geological survey.
(B) Life cycle of mining equipment.
(C) Path of exploration from discovery to production.
(D) Migration pathways of elements through Earth systems.

115. What is the fundamental principle behind using pathfinder elements in geochemical exploration?
(A) The pathfinder forms a broader dispersion halo than the target.
(B) The pathfinder is the most valuable mineral in the deposit.
(C) The pathfinder is physically easier to sample than ore.
(D) The pathfinder can only be detected using seismic methods.

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(D) Thicken the slurry before the flotation process.

36. Which mineral separation technique works on the principle of differences in the specific gravity of minerals?
(A) Magnetic separation
(B) Gravity separation
(C) Froth flotation
(D) Industrial screening

37. In the context of ancient mining and metallurgy in India, the Zawar Mines in Rajasthan are famous for the historical production of:
(A) Gold and Copper
(B) Iron and Manganese
(C) Diamond and Bauxite
(D) Lead and Zinc

38. Heavy Medium Separation (HMS), also known as dense media separation, is a specific type of:
(A) Magnetic separation
(B) Gravity separation
(C) Froth flotation
(D) Grinding process

39. Consider the following statements:
Statement I : A primary crusher accepts run-of-mine ore directly from the mine.
Statement II : A secondary crusher takes the product from the primary crusher and reduces it further in size.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

40. Consider the following comminution (size reduction) stages:
I. Grinding Mill
II. Secondary Crusher
III. Primary Crusher
Arrange the stages in the correct sequence as they typically occur in a mineral dressing plant.
(A) I, II, III
(B) III, II, I
(C) II, III, I
(D) III, I, II

41. What is the definition of the hydrological cycle?
(A) The process of artificial groundwater recharge and management.
(B) The movement of water on, above, and below the Earth's surface.
(C) The classification of aquifers based on their geological properties.
(D) The legal framework for managing international water resources.

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42. What is the ultimate origin of most groundwater?
(A) Precipitation that infiltrates the ground surface.
(B) Magmatic activity deep within the Earth.
(C) Water trapped in sediments during their deposition.
(D) Chemical reactions within the Earth's mantle.

43. Which of the following statements correctly defines an aquifer?
(A) An impermeable rock layer that prevents the flow of water.
(B) The unsaturated zone of soil above the water table.
(C) A rock formation that can store and transmit groundwater.
(D) A body of surface water such as a lake or river.

44. Darcy's Law is a fundamental principle in hydrogeology that describes the:
(A) Chemical quality of groundwater.
(B) Rate of flow of groundwater through a porous medium.
(C) Process of evaporation from a water surface.
(D) Classification of different types of aquifers.

45. Consider the following statements:
Statement I : Physical characteristics of groundwater include temperature, color, and turbidity.
Statement II : The chemical characteristics are determined by the types and amounts of dissolved substances.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

46. All of the following are methods of artificial recharge of groundwater EXCEPT:
(A) Spreading basins

127. The selection of a specific stoping method (e.g., cut-and-fill vs. shrinkage) primarily depends on:
(A) The market price of the commodity.
(B) The type of haulage equipment available.
(C) The depth of the water table.
(D) The strength of the ore and surrounding wall rock.

128. Match List I (Mining Method) with List II (Typical Deposit Type).
List I: (Mining Method)
P. Open-cast Mining
Q. Alluvial Mining
R. Room and Pillar Mining
S. Cut-and-Fill Stoping
List II: (Typical Deposit Type)
1. Gold in river gravels
2. Flat-lying coal or salt beds
3. Steeply dipping vein with weak wall rocks
4. Large, low-grade disseminated deposit near the surface
(A) P-1, Q-2, R-3, S-4
(B) P-4, Q-1, R-2, S-3
(C) P-4, Q-2, R-1, S-3
(D) P-2, Q-1, R-4, S-3

129. The main purpose of a jaw crusher in a mineral dressing circuit is:
(A) Fine grinding
(B) Magnetic separation
(C) Primary crushing
(D) Froth flotation

130. Industrial screening is a mechanical process used to:
(A) Chemically dissolve gangue minerals.
(B) Separate minerals based on their density.
(C) Separate minerals based on their surface hydrophobicity.
(D) Separate particles based on differences in their size.

131. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : Froth flotation is a very effective method for concentrating finely disseminated sulphide ores.
Reason (R) : Sulphide mineral surfaces can be made hydrophobic (water-repellent) by chemical reagents, allowing them to attach to air bubbles and float.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

132. Which property is the basis for using a spiral concentrator or a shaking table in mineral dressing?
(A) Magnetic susceptibility
(B) Specific gravity
(C) Hardness
(D) Surface wettability

133. What is the role of grinding mills in preparing ore for a process like flotation?
(A) To increase the overall size of the ore particles.
(B) To pre-heat the ore before chemical treatment.
(C) To liberate individual mineral grains from gangue.
(D) To magnetically charge the ore particles.

134. Consider the following statements about mineral dressing:
1. It is a process of physical separation.
2. It aims to reduce the volume of material processed further.
3. Crushers are used for fine grinding, while mills are used for coarse breaking.
Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

135. The evidence from Zawar Mines in Rajasthan points to sophisticated ancient knowledge in India regarding:
(A) The mining and smelting of lead-zinc ores.
(B) Open-cast coal mining.
(C) Alluvial gold panning.
(D) The application of froth flotation.

136. What is the most significant difference between surface water and subsurface water?
(A) Surface water is fresh; subsurface water is saline.

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(B) Surface exists on land; subsurface exists in pore spaces.
(C) Surface water is static; subsurface water is rapid.
(D) There is no significant difference between the two.

137. Which of the following is the primary driving force for the hydrological cycle?
(A) Geothermal heat from the Earth's core.
(B) Gravitational pull of the moon.
(C) Energy from the sun.
(D) The rotation of the Earth.

138. The term 'occurrence' in the context of groundwater refers to:
(A) The frequency of rainfall in a region.
(B) The discovery of a new spring.
(C) The chemical composition of the water.
(D) Ways water is stored within subsurface formations.

139. Which of the following rock properties is defined as the volume of void space in a rock, expressed as a percentage of the total volume?
(A) Permeability
(B) Density
(C) Resistivity
(D) Porosity

140. A high turbidity reading in a sample of groundwater would be classified as what type of characteristic?
(A) Chemical
(B) Biological
(C) Physical
(D) Hydrological

141. The construction of percolation tanks and check dams in a watershed is primarily a measure for:
(A) Flood control only.
(B) Navigation purposes.
(C) Artificial recharge of groundwater.
(D) Generating hydroelectric power.

142. The concept of 'wetland management' is important because wetlands:
(A) Provide water purification and flood control services.
(B) Are wastelands that need to be filled and developed.
(C) Are the primary source of all drinking water.
(D) Are ideal sites for disposing of industrial effluent.

143. Which of the following best describes 'natural recharge' of groundwater?
(A) Pumping water into the ground through injection wells.
(B) Natural replenishment by infiltration of precipitation.
(C) The process of water treatment in a plant.
(D) Building a dam to create a reservoir.

144. According to Darcy's Law, the flow rate of groundwater is directly proportional to the:
(A) Viscosity of the water.
(B) Hydraulic gradient.
(C) Distance of flow.
(D) Porosity of the aquifer.

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145. A 'confined aquifer' is differentiated from an 'unconfined aquifer' by the presence of:
(A) An overlying impermeable layer.
(B) A higher water temperature.
(C) Saline water instead of fresh water.
(D) A faster rate of flow.

146. A geologist uses a grid pattern to guide the collection of soil samples over a large area. This method ensures:
(A) Systematic and unbiased coverage for a survey.
(B) The immediate discovery of an ore body.
(C) The samples are all taken from the same depth.
(D) The assay results will all be identical.

147. Which of the following is NOT a form of sampling?
(A) Core sampling
(B) Channel sampling
(C) Placer sampling
(D) Air-quality sampling

148. The classification of ore reserves into categories like 'proved', 'probable', and 'possible' (or their UNFC equivalents) reflects:
(A) Increasing levels of geological confidence.
(B) Decreasing ore grade.
(C) Increasing depth of the ore body.
(D) The type of mining method to be used.

149. The process of taking the output from a drilling or sampling program and determining its mineral content in a laboratory is called:
(A) Logging
(B) Gridding
(C) Assaying
(D) Trenching

150. A significant advantage of rotary drilling in exploration is its:
(A) Ability to produce a solid core sample.
(B) Suitability for hard, abrasive rock.
(C) Relatively fast penetration in softer formations.
(D) Low initial equipment cost compared to other methods.

151. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : The magnetic geophysical method is highly effective for exploring for massive sulfide deposits that lack magnetic minerals.
Reason (R) : The magnetic method relies on detecting variations in magnetic susceptibility, which massive sulfides lacking magnetic minerals do not possess.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

152. In geochemical exploration, a 'trace element' is an element that:
(A) Is the most abundant element in the Earth's crust.
(B) Occurs in very small, but significant quantities.
(C) Is always radioactive.
(D) Is visible to the naked eye in all rock samples.

153. A sample of stream sediment is collected and analyzed. This technique is useful in geochemical exploration because the sediment:
(A) Represents a composite sample of upstream geology.
(B) Is completely free from any contamination.
(C) Is easy to analyze for physical properties.
(D) Directly indicates the depth of the ore body.

154. Consider the following statements about geobotanical exploration:
1. It involves studying vegetation to find clues about underlying geology and mineralization.
2. It is a type of geophysical method.
3. The presence of 'indicator plants' can suggest specific metal concentrations in the soil.

Which of the statements given above are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

155. Which geophysical method would be the least effective for distinguishing between a buried salt dome (low density) and a buried body of massive sulphides (high density)?
(A) Gravity method
(B) Seismic reflection method
(C) Electrical resistivity method
(D) Magnetic method

156. The choice between percussion and rotary drilling is often based on:
(A) The time of day the drilling is performed.
(B) The geological nature of the formation to be drilled.
(C) The preference of the drilling operator.
(D) The final use of the mineral to be mined.

157. Which mining term refers to the main vertical or near-vertical opening from the surface to the underground workings?
(A) A stope
(B) A drift
(C) A shaft
(D) A haulage way

158. Match List I (Mining Operation) with List II (Primary Function).
List I: (Mining Operation)
P. Drilling
Q. Blasting
R. Haulage
S. Stoping
List II: (Primary Function)
1. Transporting broken rock

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Arrange the activities in their typical chronological order.

(A) I, II, III
(B) III, II, I
(C) II, I, III
(D) III, I, II

181. The purpose of an exploratory grid is to:
(A) Provide a reference system for locating and recording data.
(B) Reinforce the ground for future mining operations.
(C) Act as a drainage system for the exploration area.
(D) Outline the final pit design.

182. A major difference between a 'syngenetic' and 'epigenetic' mineral deposit is:
(A) Timing of mineralization relative to host rock formation.
(B) The total size of the mineral deposit.
(C) The total depth of the mineral deposit.
(D) The method used for mineral dressing.

183. Which of the following geophysical methods would be most useful for directly mapping the subsurface structure of sedimentary layers, such as folds and faults?
(A) Magnetic method
(B) Gravity method
(C) Seismic reflection method
(D) Electrical resistivity method

184. The dispersion of elements like zinc and copper into the soils and streams surrounding a weathered ore body is known as:
(A) Primary dispersion
(B) Syngenetic diffusion
(C) Magnetic separation
(D) Secondary dispersion

185. Consider the following statements:
Statement I : Geochemical exploration involves the systematic measurement of the chemical properties of naturally occurring materials.
Statement II : A high concentration of a pathfinder element in a soil sample always guarantees the presence of an economic ore body directly beneath it.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

186. The main principle of percussion drilling involves:
(A) Grinding the rock away with a rotating diamond bit.
(B) Using a high-pressure jet of water to cut the rock.
(C) Breaking the rock by a series of rapid impacts.
(D) Melting the rock with a laser.

187. What is the definition of a 'stope' in underground mining?
(A) The primary vertical shaft from the surface.
(B) The equipment used for hoisting ore.
(C) A pillar of rock left for support.
(D) The excavation void from which ore has been extracted.

188. Match List I (Term) with List II (Associated Mining Type).
List I: (Term)
P. Overburden
Q. Dredge
R. Roof bolt
S. Hoist
List II: (Associated Mining Type)
1. Underground Mining (Ground Support)
2. Alluvial Mining
3. Underground Mining (Shaft transport)
4. Open-cast Mining
(A) P-1, Q-2, R-4, S-3
(B) P-4, Q-3, R-1, S-2
(C) P-4, Q-2, R-1, S-3
(D) P-2, Q-4, R-3, S-1

189. Which of these is a method for mining coal?
(A) Cut-and-fill stoping
(B) Placer mining
(C) Longwall mining
(D) Shrinkage stoping

190. Heavy medium separation, jigs, and shaking tables are all methods of:
(A) Magnetic separation
(B) Gravity separation
(C) Comminution
(D) Froth flotation

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(A) It must store and transmit water in usable quantities.
(B) It must be completely impermeable.
(C) It must be located at the Earth's surface.
(D) It must contain saline water.

170. Consider the following statements:
Statement I : Darcy's Law provides a mathematical description of groundwater flow.
Statement II : The law states that flow velocity is inversely proportional to the hydraulic conductivity.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

171. The presence of high levels of nitrate and coliform bacteria in a shallow well is often an indicator of what?
(A) Contamination from agricultural runoff or sewage.
(B) Proximity to a valuable mineral deposit.
(C) Natural radioactive decay in the bedrock.
(D) A very old and deep groundwater source.

172. The main goal of constructing check dams and gully plugs as part of watershed management is to:
(A) Slow down runoff, reduce erosion, and increase recharge.
(B) Increase the speed of surface runoff and promote erosion.
(C) Provide a direct channel for industrial waste.
(D) Create large, deep reservoirs for hydroelectric power.

173. What is meant by 'artificial recharge of groundwater'?
(A) The natural process of rain seeping into the ground.
(B) Any man-made facility that adds water to an aquifer.
(C) The process of drilling a well to extract water.
(D) The evaporation of water from a reservoir.

174. Which of these is a key component of 'wetland management'?
(A) Converting all wetlands to dry land.
(B) Preserving the hydrological and ecological functions.
(C) Using wetlands as unmanaged landfills.
(D) Introducing invasive species to increase biodiversity.

175. The upper surface of the zone of saturation in an unconfined aquifer is called the:
(A) Aquiclude
(B) Water table
(C) Bedrock
(D) Soil horizon

176. Which of the following best describes the 'mode of occurrence' of a porphyry copper deposit?
(A) A flat-lying bed in a sedimentary sequence.
(B) Disseminated mineralization with a felsic intrusion.
(C) A layer of heavy minerals in a river channel.
(D) A massive sulfide lens on the paleo-seafloor.

177. In exploration drilling, the primary output of 'core sampling' is:
(A) A physical cylinder of rock.
(B) A log of electrical measurements.
(C) A bag of rock chips.
(D) A map of the surface geology.

178. What does the 'E-axis' in the UNFC system for resource classification represent?
(A) The degree of Geological knowledge.
(B) The Economic and social viability.
(C) The level of Environmental assessment.
(D) The Exploration methodology used.

179. A team is evaluating a narrow, vertical vein of gold ore exposed in a tunnel. Which sampling method would provide the most reliable estimate of the vein's average grade?
(A) Taking a few random grab samples from the floor.
(B) Drilling a single vertical hole parallel to the vein.
(C) Sampling the host rock several meters away.
(D) Cutting a continuous horizontal channel across the vein.

180. Consider the following exploration activities:
I. Core drilling and sampling
II. Calculation of ore reserves
III. Regional geological mapping and

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202. The grade of an ore, determined through assaying, is a measure of:
(A) The concentration of the valuable mineral or metal.
(B) The total volume of the ore body.
(C) The hardness of the ore on the Mohs scale.
(D) The depth at which the ore is located.

203. The F-axis in the UNFC system for resource classification stands for:
(A) Financial viability.
(B) Formation type.
(C) Field exploration stage.
(D) Feasibility assessment status.

204. Consider the following statements:
Statement I : Placer sampling is the most appropriate method for evaluating deep, hard-rock vein deposits.
Statement II : It is used to evaluate unconsolidated deposits of heavy minerals in environments like riverbeds.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

205. The primary difference between a geophysical and a geochemical survey is that:
(A) Geophysics measures physical traits; geochemistry chemical ones.
(B) Geophysics is ground-based; geochemistry is airborne.
(C) Geophysics are direct methods; geochemistry are indirect.
(D) Geophysics is for metals; geochemistry for industrial minerals.

206. The tendency of an element to be leached from a rock by groundwater and transported away is a function of its:
(A) Mobility in the geochemical cycle.
(B) Atomic weight.
(C) Magnetic susceptibility.
(D) Hardness.

207. Which of the following situations would produce the most prominent magnetic anomaly?
(A) A granite intrusion surrounded by gneiss.
(B) A sandstone layer overlying a shale layer.
(C) A low-density salt dome within sediments.
(D) A vertical body of magnetite within limestone.

208. The term 'pathfinder' is used for an element that:
(A) Is geochemically associated and more easily found.
(B) Is the primary economic commodity being sought.
(C) Is always a radioactive element.
(D) Is used to calibrate geophysical instruments.

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209. The classification of mining methods into 'open-cast' and 'underground' is primarily based on:
(A) The commodity being mined.
(B) The country in which the mining occurs.
(C) The age of the deposit.
(D) Whether ore is extracted from the surface or tunnels.

210. Which piece of equipment is central to the 'haulage' system in a large open-pit mine?
(A) A large dump truck
(B) A raise borer
(C) A hoist in a shaft
(D) A roof-bolting machine

211. In underground mining, what is the main purpose of 'stoping'?
(A) To sink the main access shaft.
(B) To drive horizontal development tunnels.
(C) To explore for new ore zones.
(D) To carry out the bulk extraction of the ore body.

212. All of the following physical properties are used as the basis for a mineral dressing separation technique EXCEPT:
(A) Specific Gravity
(B) Radioactivity
(C) Magnetic Susceptibility
(D) Surface Wettability

213. A 'ball mill' or 'rod mill' is a type of:
(A) Primary crusher
(B) Secondary crusher
(C) Grinding mill
(D) Screening equipment

214. Which method of separation would be most effective for separating cassiterite (a dense tin

191. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : Industrial screening is used to separate ore particles into different size fractions.
Reason (R) : Subsequent processes like grinding or concentration are often most efficient when fed with material of a specific size range.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

192. Which mineral dressing technique exploits the differences in surface chemistry of minerals, making some float and others sink?
(A) Heavy Medium Separation
(B) Magnetic Separation
(C) Industrial Screening
(D) Froth Flotation

193. The historical significance of the Zawar Mines in Rajasthan is related to its long history of:
(A) Lead-zinc mining and smelting.
(B) Diamond mining and cutting.
(C) Iron ore extraction for steel production.
(D) Alluvial gold recovery.

194. Consider the following equipment used in mineral dressing:
1. Jaw Crusher
2. Ball Mill
3. Screen
Which of these are primarily used for size reduction (comminution)?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

195. What is the primary difference between porosity and permeability?
(A) Porosity applies to rocks; permeability to soils.
(B) Porosity measures storage; permeability measures flow.
(C) Porosity is in meters/day; permeability is a percentage.
(D) There is no difference; the terms are synonymous.

196. The process by which water vapor in the atmosphere cools, condenses, and falls to the Earth as rain or snow is called:
(A) Precipitation
(B) Infiltration
(C) Runoff
(D) Evaporation

197. An unconfined aquifer is one in which:
(A) The water is held under pressure between two layers.
(B) The water is saline and not fit for consumption.
(C) There is no water present in the formation.
(D) The water table forms the upper boundary.

198. Which of the following is NOT a physical characteristic of groundwater?
(A) Temperature
(B) pH
(C) Turbidity
(D) Color

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199. The practice of building structures like contour bunds and terraces as part of watershed management primarily aims to:
(A) Increase the rate of water flow down slopes.
(B) Promote deforestation for agricultural expansion.
(C) Conserve soil and water and increase infiltration.
(D) Channelize rivers for faster drainage.

200. An injection well is a technology used for:
(A) Artificial recharge of groundwater.
(B) Natural recharge of groundwater.
(C) Extracting groundwater for irrigation.
(D) Measuring the water table depth.

201. Which of the following is an example of an exploration technique that involves direct observation and sampling of near-surface material?
(A) Airborne magnetic survey
(B) Regional gravity survey
(C) Trenching
(D) Seismic reflection profiling

(B) Primary occurs during formation; secondary occurs later.
(C) Primary happens at depth; secondary happens at surface.
(D) Primary is vertical; secondary is horizontal.

224. Consider the following geophysical methods:
1. Gravity Method
2. Magnetic Method
3. Seismic Method

Which of these methods measure a potential field (a naturally existing field of the Earth)?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

225. A rotary drilling rig is most analogous in its cutting action to:
(A) A hammer and chisel.
(B) An electric hand drill.
(C) A pressure washer.
(D) A sandblaster.

226. 'Stoping methods' is a term that applies to the classification of excavation techniques within:
(A) Alluvial mining
(B) Underground mining
(C) Placer sampling
(D) Surface mining

227. A key difference between haulage and winding in a deep underground mine is that:
(A) Haulage is horizontal; winding is vertical transport.
(B) Haulage moves people; winding moves ore.
(C) Haulage is by machine; winding is by hand.
(D) Haulage is part of exploration; winding is part of mining.

228. What is the primary goal of the crushing and grinding stages in mineral dressing?
(A) To reduce particle size and liberate minerals from gangue.
(B) To chemically alter the minerals.
(C) To increase the magnetic susceptibility of the ore.
(D) To directly produce a pure metal product.

229. The froth flotation process for concentrating sulphide ores relies on controlling which property of the mineral surfaces?
(A) Density
(B) Hardness
(C) Wettability (hydrophobicity/hydrophilicity)
(D) Radioactivity

230. The origin of groundwater is predominantly from:
(A) Juvenile water from the Earth's mantle.
(B) Meteoric water originating as precipitation.
(C) Connate water trapped in sediments.
(D) Seawater intrusion along all coastlines.

231. Which term describes a rock's ability to allow water to pass through it?
(A) Porosity
(B) Aquiclude
(C) Water table
(D) Permeability

232. Consider the following statements:
Statement I : Groundwater always flows from a higher elevation to a lower elevation.
Statement II : Groundwater flows from a point of higher hydraulic head to a point of lower hydraulic head, which may not always correspond to lower elevation.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

233. The concept of 'watershed management' is based on the principle that:
(A) It is most effective to manage resources within a basin.
(B) Political boundaries are more important than hydrological.
(C) Groundwater and surface systems should be unrelated.
(D) The only goal is to maximize immediate water extraction.

234. Which of the following is NOT a method of artificial groundwater recharge?
(A) Spreading water over the surface in basins.
(B) Transpiration by trees.
(C) Constructing check dams to hold back runoff.

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oxide, specific gravity ~7) from quartz (less dense, specific gravity ~2.7)?
(A) Magnetic separation
(B) Froth flotation
(C) Industrial screening
(D) Gravity separation

215. What is the importance of groundwater as a resource?
(A) It is the largest source of fresh, liquid water available.
(B) It is only important in desert regions.
(C) It is a non-renewable resource that cannot be replenished.
(D) It is generally too polluted for any use.

216. A rock layer composed of unfractured, dense granite would most likely be classified as:
(A) An aquiclude
(B) An aquifer
(C) A river
(D) A wetland

217. The primary purpose of watershed management is to:
(A) Manage resources in a holistic way within a drainage basin.
(B) Focus exclusively on the construction of dams.
(C) Promote rapid urbanization within watershed boundaries.
(D) Encourage practices that lead to maximum soil erosion.

218. Match List I (Hydrogeological Concept) with List II (Relevance).
List I: (Hydrogeological Concept)
P. Hydrological Cycle
Q. Aquifer Classification
R. Darcy's Law
S. Water Harvesting
List II: (Relevance)
1. Differentiating between confined and unconfined systems
2. Capturing and storing rainwater
3. Describing the continuous global movement of water
4. Quantifying groundwater flow rates
(A) P-1, Q-3, R-2, S-4
(B) P-3, Q-1, R-4, S-2
(C) P-3, Q-2, R-4, S-1
(D) P-4, Q-1, R-2, S-3

219. Which action is an example of artificial groundwater recharge?
(A) Allowing rain to naturally soak into the ground.
(B) Diverting stream water into spreading basins.
(C) Pumping water out of a well.
(D) The process of transpiration from plants.

220. The evaluation of a mineral deposit via exploratory grids, pitting, and trenching are all methods primarily aimed at understanding:
(A) The deep, internal structure of the Earth.
(B) The near-surface geology and geometry of the ore body.
(C) The process of mineral dressing.
(D) The design of the mine's winding system.

221. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : Core sampling is generally more expensive per meter than non-coring drilling methods.
Reason (R) : It requires specialized equipment to recover an intact rock core and is a slower process, but it provides invaluable geological information.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

222. The final calculation of ore reserves combines geological data on volume and grade with:
(A) The personal preferences of the mine manager.
(B) Political considerations and public opinion.
(C) Economic and technical factors to assess profitability.
(D) The results of geobotanical surveys only.

223. What is the fundamental difference between 'primary' and 'secondary' dispersion in geochemistry?
(A) Primary involves valuable metals; secondary involves waste.

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2. Creating holes for explosives
3. Excavating the ore body
4. Fracturing the rock mass

(A) P-2, Q-4, R-1, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-3, R-4, S-1
(D) P-4, Q-1, R-2, S-3

159. For a thick, flat-lying coal seam located hundreds of meters below the surface, which mining method would be most appropriate?
(A) Alluvial mining
(B) Open-cast mining
(C) Longwall or Room and pillar mining
(D) Hydraulic mining

160. What is a significant disadvantage of the room and pillar mining method compared to longwall mining?
(A) It can only be used at very shallow depths.
(B) A significant amount of the resource is left behind.
(C) It requires more sophisticated and expensive equipment.
(D) It causes more surface subsidence.

161. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : In cut-and-fill stoping, waste rock or other fill material is placed into the excavated stope after the ore is removed.
Reason (R) : The primary purpose of the fill is to provide ground support for the walls and a working platform for the next level of mining.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

162. The physical properties of minerals, such as density and magnetism, are utilized in mineral dressing to:
(A) Achieve separation without the use of chemical reagents.
(B) Change the chemical composition of the minerals.
(C) Increase the hardness of the ore.
(D) Assay the final concentrate.

163. The term 'comminution' in mineral dressing refers to the overall process of:
(A) Size reduction, including crushing and grinding.
(B) Size separation, such as screening.
(C) Concentration, such as flotation.
(D) Dewatering, such as thickening.

164. Consider the following statements related to mineral separation:
1. Heavy medium separation is a type of gravity separation.
2. Froth flotation separates minerals based on density.
3. Magnetic separation is effective for all types of minerals.

Which of the statements given above are correct?
(A) 1 only
(B) 2 only
(C) 1 and 3 only
(D) 2 and 3 only

165. In froth flotation, 'hydrophobic' particles are those that:
(A) Repel water and attach to air bubbles.
(B) Readily attract water and sink.
(C) Are magnetic.
(D) Are extremely dense.

166. A primary gyratory crusher is best suited for:
(A) Very fine grinding of ore into a powder.
(B) High-capacity crushing of large, hard rock.
(C) Separating sulphide ores from gangue.
(D) Screening ore into different size fractions.

167. The hydrological properties of rocks that are most important for hydrogeology are:
(A) Color and luster.
(B) Age and fossil content.
(C) Porosity and permeability.
(D) Density and magnetic susceptibility.

168. Which process is NOT part of the hydrological cycle?
(A) Evaporation
(B) Precipitation
(C) Infiltration
(D) Lithification

169. What is the fundamental requirement for a rock formation to be classified as an aquifer?

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(D) Injecting water directly into an aquifer using a well.

235. The purpose of underground mining sampling is to:
(A) Determine the best location for the mine office.
(B) Guide operations, control grade, and reconcile estimates.
(C) Fulfill a requirement for surface exploration permits.
(D) Test the efficiency of the winding equipment.

236. The UNFC provides a framework to classify mineral deposits based on three fundamental criteria:
(A) Size, Shape, and Depth of the deposit.
(B) Hardness, Color, and Luster of the minerals.
(C) Economic Viability, Feasibility Assessment, and Geology.
(D) Mining Method, Processing Technique, and Marketing.

237. A geobotanical anomaly, such as chlorosis (yellowing) in leaves or the presence of specific indicator plants, is caused by:
(A) Variations in the Earth's magnetic field.
(B) Differences in rock density.
(C) The effects of seismic waves on plant roots.
(D) Abnormal element concentrations derived from ore.

238. In the context of the geochemical cycle, which environment would promote high mobility of elements that are soluble under oxidizing conditions?
(A) Near-surface environment with oxygenated rainwater.
(B) A deep, stagnant, oxygen-poor swamp.
(C) A zone of contact metamorphism deep in the crust.
(D) The interior of a freshly crystallized igneous rock.

239. The most significant difference between coal mining methods and other underground (non-coal) mining methods is:
(A) Coal is in sedimentary strata, favoring longwall mining.
(B) Coal mining does not require any ventilation.
(C) Metal mining does not use explosives.
(D) Coal mining is always done on the surface.

240. The transition from primary crushing to secondary crushing and then to grinding represents a move towards:
(A) Increasing particle size.
(B) Progressively finer particle size reduction.
(C) Changing the chemical properties of the ore.
(D) Separating minerals based on density.

241. Heavy Medium Separation is a concentration process that belongs to which broader category of mineral dressing?
(A) Magnetic Separation
(B) Flotation
(C) Gravity Separation
(D) Comminution

242. The historical mining at Zawar, Rajasthan, is a significant example of ancient metallurgy in India primarily because of the evidence of large-scale:
(A) Gold refining.
(B) Distillation of zinc from its ore.
(C) Diamond cutting and polishing.
(D) Aluminum production.

243. The continuous circulation of water from the oceans to the atmosphere, to the land, and back to the sea is called the:
(A) Rock Cycle
(B) Hydrological Cycle
(C) Geochemical Cycle
(D) Mining Cycle

244. A body of rock or sediment that can store water but does not transmit it in significant quantities is called an:
(A) Aquifer
(B) Aquitard
(C) Aquifuge
(D) Artesian well

245. High concentrations of dissolved iron and manganese in groundwater are examples of its:
(A) Physical characteristics.
(B) Chemical characteristics.
(C) Biological characteristics.
(D) Hydrological properties.

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265. What is the fundamental principle of the gravity separation method in mineral dressing?
(A) Differences in magnetic susceptibility between minerals.
(B) Differences in specific gravity (density) of minerals.
(C) Differences in the surface wettability of minerals.
(D) Differences in the particle size of the ore.

266. A confined aquifer is more protected from surface pollution than an unconfined aquifer because:
(A) It is overlain by an impermeable layer (aquiclude).
(B) It is located at a much higher elevation.
(C) The water in it is always flowing at a very high velocity.
(D) It contains saltwater which neutralizes pollutants.

267. The main purpose of geobotanical exploration is to:
(A) Identify the most fertile areas for farming.
(B) Use plant chemistry as an indicator of mineralization.
(C) Create a catalogue of all plant species in a region.
(D) Study the effects of acid rain on forests.

268. Which of the following is an active, not passive, geophysical method?
(A) Gravity method
(B) Magnetotelluric method
(C) Magnetic method
(D) Seismic reflection method

269. The room and pillar method is a common technique used in:
(A) Alluvial mining for gold.
(B) Open-cast mining of copper.
(C) The excavation of vertical shafts.
(D) Mining flat-lying deposits like coal or salt.

270. The historical significance of Zawar mines is related to its role as an example of:
(A) Modern hydrogeological management.
(B) Ancient mining and metallurgy in India.
(C) A type locality for a specific mineral.
(D) The first use of froth flotation.

271. What does Darcy's Law fundamentally relate?
(A) Groundwater quality to rock type.
(B) Flow velocity to hydraulic gradient and conductivity.
(C) The rate of evaporation to temperature.
(D) The classification of aquifers to their depth.

272. In the context of the hydrological cycle, 'infiltration' refers to the process where:
(A) Water turns from liquid to vapor.
(B) Water vapor turns into clouds.
(C) Water moves from the surface into the ground.
(D) Water flows over the land surface into rivers.

273. The term 'ore reserves' implies that the material is not only discovered but also:
(A) Has been fully mined out.
(B) Is located on the surface.
(C) Is legally and economically extractable at a profit.
(D) Belongs to a government agency.

274. In a geochemical survey, a 'primary dispersion' pattern refers to the distribution of elements that occurred:
(A) Due to weathering and erosion at the surface.
(B) During and around the original ore-forming event.
(C) In the leaves of plants growing over the deposit.
(D) In the stream sediments miles away from the source.

275. Consider the following statements:
Statement I : Open-cast mining involves removing surface material to expose and extract the ore.
Statement II : Stoping is a general term for excavation methods used in underground mining.
(A) Both Statement I and Statement II are true.
(B) Both Statement I and Statement II are false.
(C) Statement I is true, but Statement II is false.
(D) Statement I is false, but Statement II is true.

276. What physical property is exploited during magnetic separation of minerals?
(A) Density
(B) Surface tension

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(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

255. The choice between open-cast and underground mining is most critically dependent on:
(A) The depth and geometry of the ore deposit.
(B) The specific colour of the ore under natural light.
(C) The political climate and stability of the region.
(D) Availability of water for mineral processing.

256. A geological formation described as having high porosity but very low permeability, such as clay, is best classified as an:
(A) Aquitard
(B) Aquifer
(C) Underground river
(D) Open channel

257. What is the primary aim of 'water harvesting'?
(A) To extract as much groundwater as possible in the shortest time.
(B) To capture and store precipitation for dry periods and recharge.
(C) To create decorative water features in urban areas.
(D) To transfer water from one river basin to another.

258. The 'mode of occurrence of trace elements' is important in geochemical exploration because:
(A) It dictates which geophysical method to use.
(B) It determines release and detection of anomalies.
(C) It is the sole factor in calculating ore reserves.
(D) It determines the final price of the commodity.

259. A significant environmental benefit of effective watershed management is:
(A) Increased rates of soil erosion and reservoir siltation.
(B) Promotion of deforestation.
(C) Reduced soil erosion and improved water quality.
(D) Elimination of all regional wetlands.

260. Consider the following processes:
I. Precipitation
II. Infiltration
III. Evaporation
Arrange the following processes in the hydrological cycle in a logical sequence, starting from water in the ocean.
(A) I, II, III
(B) III, I, II
(C) II, I, III
(D) III, II, I

261. In underground mining, the system for vertical transport in a shaft is called 'winding', while the system for horizontal transport in tunnels is called:
(A) Stoping
(B) Drilling
(C) Haulage
(D) Crushing

262. Which of the following statements about 'channel sampling' is correct?
(A) It involves collecting random, disconnected pieces of rock.
(B) It cuts a continuous groove of uniform size across a face.
(C) It is a geophysical technique that uses electrical channels.
(D) It is only used for sampling water in river channels.

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263. A key difference between 'resources' and 'reserves' in the UNFC system is that 'reserves' are:
(A) Known to exist, but are not economically or technically viable to mine.
(B) The portion demonstrated to be economically mineable.
(C) A purely geological estimate, without any economic consideration.
(D) Always smaller in grade than resources.

264. The primary function of a grinding mill in a mineral processing circuit is to:
(A) Perform coarse crushing of large boulders.
(B) Reduce crushed ore to a fine powder to liberate grains.
(C) Sort ore by particle size.
(D) Dewater the ore slurry.

246. Well logging is a technique used during the evaluation of deposits that involves:
(A) Keeping a manual diary of drilling progress.
(B) Creating a detailed map of all wells in a district.
(C) Lowering instruments to measure rock properties.
(D) Taking water level measurements in a completed well.

247. The primary reason for using a systematic exploratory grid is to:
(A) Avoid missing a potential ore body due to haphazard exploration.
(B) Fulfill a legal requirement for land ownership.
(C) Build roads for the future mine.
(D) Practice drilling techniques.

248. Match List I (Mineral Processing Stage) with List II (Primary Equipment).
List I: (Mineral Processing Stage)
P. Primary Crushing
Q. Grinding
R. Sizing
S. Gravity Separation
List II: (Primary Equipment)
1. Ball Mill
2. Jaw Crusher
3. Shaking Table
4. Screen
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-1, R-4, S-3
(C) P-2, Q-4, R-1, S-3
(D) P-3, Q-1, R-4, S-2

249. What is the key principle of the seismic exploration method?
(A) It detects variations in rock density.
(B) It maps changes in the Earth's magnetic field.
(C) It analyzes travel times of sound waves in the subsurface.
(D) It measures the electrical conductivity of the ground.

250. The term 'syngenetic diffusion' describes the dispersion of elements that occurs:
(A) During the formation of the host rock itself.
(B) Long after the host rock has formed, due to weathering.
(C) Only in the botanical environment.
(D) As a result of mining activities.

251. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : An artesian well is one in which water rises above the top of the aquifer without pumping.
Reason (R) : This occurs when a well penetrates a confined aquifer where the water is under pressure, and the potentiometric surface is above the ground level.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

252. The term 'stoping' in mining is best described as:
(A) The process of drilling and blasting.
(B) Systematic excavation of ore between levels or drifts.
(C) The backfilling of mined-out areas with waste.
(D) The process of ceasing all operations in a mine.

253. In a mineral dressing plant, the purpose of a 'crusher' is different from a 'grinding mill' in that:
(A) Crushers handle finer material than grinding mills.
(B) Crushers use chemical reagents, while mills do not.
(C) Crushers separate minerals by density, while mills separate by size.
(D) Crushers are used for initial, coarse size reduction.

254. Consider the following statements about hydrogeology:
1. Darcy's law describes the quality of groundwater.
2. An aquifer must be both porous and permeable.
3. The hydrological cycle is a closed system driven by solar energy.
Which of the statements given above are correct?

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(C) Magnetic susceptibility
(D) Hardness

277. The classification of groundwater reservoirs as 'unconfined' or 'confined' is based on:
(A) The chemical quality of the water.
(B) The presence of an overlying impermeable layer.
(C) The depth of the water table.
(D) The temperature of the water.

278. Which of the following is a primary goal of integrated watershed management?
(A) To maximize deforestation.
(B) To accelerate soil erosion.
(C) To manage resources of a basin for sustainable use.
(D) To focus only on groundwater extraction.

279. The purpose of assaying a sample from a mineral deposit is to:
(A) Determine its age.
(B) Determine its physical strength.
(C) Determine the concentration of valuable metals.
(D) Determine its magnetic properties.

280. What is the key difference between percussion and rotary drilling?
(A) Percussion hammers rock; rotary breaks by grinding.
(B) Percussion is for shallow holes; rotary for deep holes.
(C) Percussion uses water; rotary uses air.
(D) Percussion is mining; rotary is exploration.

281. The froth flotation technique is used for the separation of:
(A) Oxide ores
(B) Sulphide ores
(C) Silicate minerals
(D) Heavy minerals in placer deposits

282. The term 'hydrological properties of rocks' primarily refers to their:
(A) Age and fossil content.
(B) Color and texture.
(C) Porosity and permeability.
(D) Chemical composition.

283. Which of the following would be an example of 'artificial recharge'?
(A) Natural seepage from a river into its banks.
(B) Rainfall infiltrating into the soil of a forest.
(C) Pumping treated wastewater into a well to replenish.
(D) Snowmelt running off a mountain slope.

284. A large, low-grade mineral deposit exposed at the surface would most economically be mined by which method?
(A) Shrinkage stoping
(B) Cut-and-fill stoping
(C) Open-cast mining
(D) Room and pillar mining

285. In mineral exploration, a 'pathfinder element' is useful because it:
(A) Forms a larger and more detectable geochemical halo.
(B) Is more valuable than the element being sought.
(C) Can only be detected by seismic surveys.
(D) Is always found in pure, native form.

286. 'Winding' is a mining term for:
(A) The horizontal transport of ore along a tunnel.
(B) The ventilation system of an underground mine.
(C) Vertical transport of men and materials in a shaft.
(D) The sinuous path of an exploratory trench.

287. Which of the following is a key component of the 'hydrological cycle'?
(A) Mineral dressing
(B) Stoping
(C) Evaporation
(D) Assaying

288. A 'jaw crusher' is used in the mineral dressing process for:
(A) Fine grinding of ore into powder.
(B) Primary, coarse crushing of run-of-mine ore.
(C) Separating magnetic minerals.
(D) Pumping slurry.

289. Which statement best defines a 'watershed'?
(A) A facility for storing water.

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(B) Area where all surface water drains to a common point.
(C) A type of underground aquifer.
(D) A political boundary for water resource allocation.

290. The gravity method of geophysical exploration is based on detecting subsurface variations in:
(A) Electrical resistivity
(B) Density
(C) Magnetic susceptibility
(D) Seismic velocity

291. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A) : In an unconfined aquifer, the water level in a well corresponds to the water table.
Reason (R) : An unconfined aquifer has a free water surface that is open to atmospheric pressure.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

292. Core sampling is a preferred exploration drilling method when:
(A) The fastest possible drilling speed is the only priority.
(B) Detailed info on rock type and texture is required.
(C) The ground is too soft for any other method.
(D) Only a surface sample is needed.

293. The purpose of a geochemical exploration survey is to:
(A) Identify anomalies indicating potential mineralization.
(B) Measure the density of rocks.
(C) Create a grid for mine planning.
(D) Test the efficiency of crushing equipment.

294. Consider the following mining methods:
1. Longwall mining
2. Room and pillar mining
3. Open-cast mining
Which of these are methods used for mining coal?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2, and 3

295. Heavy medium separation is a technique that separates mineral particles based on their:
(A) Size
(B) Shape
(C) Density
(D) Magnetic attraction

296. The distribution of water between surface and subsurface reservoirs is a key aspect of:
(A) Mineral dressing
(B) Mining terminology
(C) Hydrogeology
(D) Geochemical exploration

297. A key difference between natural and artificial recharge of groundwater is that artificial recharge:
(A) Happens without human intervention.
(B) Involves engineered systems to augment storage.
(C) Only occurs in coastal areas.
(D) Is part of the geochemical cycle.

298. The primary purpose of 'industrial screening' in a mineral processing plant is to:
(A) Reduce the size of large rocks.
(B) Separate particles into different size fractions.
(C) Concentrate valuable minerals using water.
(D) Add chemical reagents to the ore.

299. In which mining method is the overburden (waste material above the ore) systematically removed to expose the ore for excavation?
(A) Room and pillar mining
(B) Cut-and-fill stoping
(C) Open-cast mining
(D) Shrinkage stoping

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300. Which law provides the fundamental equation for calculating the rate of groundwater flow through a porous medium?
(A) Newton's Law
(B) Ohm's Law
(C) Darcy's Law

(D) The Law of Superposition

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ANSWERS

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1. (B) To provide a systematic framework for geological mapping and sampling.
Creating an exploratory grid involves establishing a network of reference points across a survey area. This systematic framework allows geologists to accurately map geological features and collect samples at regular intervals. Such precision ensures that no significant mineralized zones are overlooked during the initial phase of exploration, providing a reliable basis for subsequent drilling and evaluation.

2. (A) Core sampling
Core sampling is a primary technique used to retrieve intact, cylindrical rock samples from deep beneath the surface. By using a hollow drill bit, geologists can extract continuous sections of the earth, preserving the original structure, texture, and mineral content. This direct method is essential for detailed stratigraphic analysis and precise estimation of ore grade in subsurface deposits.

3. (C) It involves lowering instruments into a borehole to record physical properties.
Well logging is an indirect subsurface exploration technique that involves lowering specialized probes or sensors into a borehole. These instruments measure various physical properties of the surrounding rock formations, such as electrical resistivity, natural gamma radiation, and density. The resulting data provides a continuous profile of the subsurface geology without the need for physical sample extraction in every instance.

4. (D) Digging a long, narrow trench
Trenching is a highly effective surface exploration method for investigating shallow or near-surface mineralization. By excavating a long and narrow opening, geologists can observe a continuous cross-section of the local geology and take representative samples. This approach is particularly useful for mapping the extent of flat-lying ore bodies that are covered by only a thin layer of soil.

5. (C) Statement I is true, but Statement II is false.
Channel sampling is a rigorous method that involves cutting a uniform groove across a mineralized face to collect a representative sample. In contrast, grab sampling involves picking random pieces of rock, which often introduces bias and fails to represent the entire ore body accurately. Therefore, systematic methods like channel sampling are preferred for reliable grade estimation and resource calculation.

6. (B) The market price of the final refined metal.
Calculating ore reserves primarily requires detailed information about the physical characteristics of a deposit, including its total volume, tonnage, and average mineral grade. Geological confidence in the data is also vital for classification. While the market price of refined metal influences the economic viability of a project, it is not an inherent physical component of the ore reserve.

7. (D) It is primarily designed for classifying rock types rather than resources.
The United Nations Framework Classification is a sophisticated system used to categorize mineral resources and reserves based on three fundamental criteria. These include geological confidence, feasibility assessment, and economic or social viability. It is specifically designed to standardize the reporting of mineral assets globally rather than serving as a system for the general classification of various rock types.

8. (A) P-3, Q-4, R-1, S-2
Mineral exploration utilizes diverse techniques for specific objectives. Pitting and trenching expose near-surface mineralization for direct observation. Core drilling retrieves cylindrical rock samples from depth to analyze subsurface geology. Well logging records physical properties through instruments lowered into boreholes. Placer sampling is specifically used to evaluate unconsolidated deposits, such as gold found in riverbeds or other surficial environments.

9. (C) The chemical analysis of a sample to determine mineral concentration.
Assaying is a fundamental process in mineral exploration that involves the precise chemical analysis of samples to determine the concentration of valuable metals or minerals. This quantitative measurement is critical for estimating the grade of an ore deposit. The results from assaying directly influence the economic evaluation and determine whether a site is viable for commercial mining operations.

10. (A) It measures shock wave travel times through reflection and refraction.
The seismic method is a geophysical technique that relies on the propagation of sound waves through the Earth. By generating controlled shock waves and measuring their travel times as they reflect or refract off different subsurface layers, geologists can map complex geological structures. This method is particularly effective for identifying oil traps, faults, and stratigraphic boundaries in sedimentary basins.

11. (A) Both A and R are true and R is the correct explanation of A.
Pathfinder elements are chemical elements that occur in association with a target ore but are easier to detect or more mobile in the environment. Their presence creates a larger dispersion halo, making them invaluable for leading geologists toward hidden mineral deposits. Using these indicators significantly enhances the efficiency of geochemical exploration programs by providing broader targets for initial reconnaissance.

12. (B) The dispersion of elements occurring during host rock or deposit formation.
Primary dispersion refers to the distribution of chemical elements that occurs during the original formation of an ore deposit and its surrounding host rock. This process results in the creation of geochemical halos within the solid bedrock. Analyzing these patterns helps geologists understand the hydrothermal or magmatic processes that concentrated the minerals and aids in locating the core deposit.

13. (C) Electrical method - Electrical conductivity/ resistivity
Geophysical exploration relies on detecting contrasts in the physical properties of subsurface materials. The electrical method specifically measures the conductivity or resistivity of rocks and minerals to identify potential ore bodies. Other methods, such as gravity or magnetic surveys, focus on density and magnetic susceptibility, respectively. Selecting the appropriate method depends on the physical characteristics of the target mineral.

14. (C) 1 and 3 only
Geochemical exploration is based on the movement of elements through various Earth systems, known as the geochemical cycle. Primary dispersion occurs during deposit formation, while secondary dispersion involves the redistribution of elements through weathering and surface processes. Unlike static properties, the mobility of elements in the environment is heavily influenced by external factors such as pH and redox potential.

15. (A) Geobotanical exploration
Geobotanical exploration is a specialized technique that involves the study of vegetation patterns to identify underlying mineral deposits. Certain plant species, known as indicator plants, thrive in soils with high concentrations of specific metals. By mapping the distribution of these plants or observing abnormalities in plant growth, geologists can detect potential mineralization that is hidden beneath the surface.

16. (B) Gravity method
The gravity method is an effective geophysical technique used to detect subsurface bodies that have a different density than the surrounding rocks. When a buried ore body is significantly denser, it causes a localized increase in the Earth's gravitational field, known as a positive anomaly. Measuring these variations allows geophysicists to map the shape and depth of deposits.

17. (B) Arsenic (As)
Arsenic is frequently used as a pathfinder element for gold deposits because of its close geochemical association and greater mobility in the weathering environment. It often forms a wider dispersion halo in soil and stream sediments than gold itself. Detecting elevated arsenic levels provides geologists with a larger target, facilitating the discovery of the primary gold mineralization located nearby.

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18. (A) Water sampling is only useful for detecting physical sediments.
Geochemical exploration utilizes various sampling media to detect dispersion halos. Soil and stream sediment sampling are effective for identifying secondary patterns, while rock chip sampling reveals primary dispersion. Contrary to the idea that it only detects physical sediments, water sampling is a powerful tool for finding dissolved ions and trace elements that have been leached from hidden mineral deposits.

19. (A) Both Statement I and Statement II are true.
The timing of element dispersion relative to host rock formation is categorized as syngenetic or epigenetic. Syngenetic diffusion happens contemporaneously with the formation of the host rock, integrating elements into the original structure. In contrast, epigenetic diffusion involves the introduction of elements into pre-existing rocks, typically through hydrothermal fluids. Both processes create distinct geochemical patterns used in mineral exploration.

20. (D) Materials offer varying opposition to the flow of an electric current.
The electrical resistivity method operates on the principle that different subsurface materials offer varying degrees of opposition to the flow of an electric current. By injecting current into the ground and measuring the resulting potential difference, geophysicists can calculate the resistivity of various layers. This technique is particularly useful for identifying conductive ore bodies, groundwater aquifers, and structural features.

21. (C) Horizontal transport of ore and waste to the surface or shaft.
Haulage is a critical operation in mining that involves the horizontal transportation of ore, waste rock, and materials within the mine workings. This process moves extracted material from the production face to a central collection point, such as a shaft or a surface portal. Efficient haulage systems, using trucks, conveyors, or rail cars, are essential for maintaining continuous production.

22. (D) It employs a rapid succession of blows to hammer the rock.
Percussion drilling is characterized by a mechanical action that employs a rapid succession of powerful blows to hammer a bit into the rock. This hammering action shatters the rock into small chips, which are then removed from the hole. It differs fundamentally from rotary drilling, which relies on a grinding or cutting action to penetrate the subsurface formations during exploration.

23. (C) It extracts minerals from unconsolidated sand and gravel in riverbeds.
Alluvial mining, also known as placer mining, is a surface extraction method used for minerals found in unconsolidated deposits. These deposits typically consist of sand, gravel, and silt located in riverbeds or floodplains. The process involves separating heavy valuable minerals, such as gold or tin, from the lighter waste material using water and gravity-based techniques like panning or dredging.

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24. (D) Open-cast mining
Open-cast mining is the most suitable method for extracting large, low-grade ore bodies located near the surface. This technique involves removing the overlying waste rock to create a massive open pit, allowing for high-volume production at a relatively low cost. It is commonly used for disseminated deposits, such as porphyry copper, where the scale of operation justifies the surface excavation.

25. (C) Statement I is true, but Statement II is false.
Stoping is the fundamental process of excavating ore from an underground mineral deposit. The void or opening that remains after the valuable ore has been removed is specifically called a stope. While stoping refers to the act of extraction, the stope itself is the resulting workspace. Understanding these terms is essential for describing the geometry and progress of underground operations.

26. (B) Overburden stripping
Underground mining employs various stoping methods, such as cut-and-fill, shrinkage, and room and pillar stoping, depending on the geological conditions. These techniques focus on extracting ore from beneath the surface.

Overburden stripping, however, is a process exclusive to surface mining, where the waste material covering a deposit is removed to expose the ore body for extraction in open pits.

27. (D) Coal is exclusively mined using alluvial gold mining techniques.
Coal mining involves several specialized techniques depending on the depth and orientation of the seams. Underground methods include longwall mining, which uses large shearing machines, and room and pillar mining, which leaves coal supports. Near-surface seams are extracted via open-cast or strip mining. The claim that coal is exclusively mined using alluvial techniques is incorrect as coal is not a placer.

28. (B) P-3, Q-2, R-4, S-1
Mining operations involve specialized terminology for different processes. Winding refers to the vertical hoisting of personnel and materials through a shaft. A stope is the void created when ore is extracted underground. Haulage describes the horizontal movement of materials within the mine. Alluvial mining is the extraction of minerals from placer deposits, such as those found in river gravels.

29. (C) To transport materials and personnel vertically through a shaft.
Winding equipment, including hoists and cages, is vital for the operation of deep underground mines. Its primary function is to provide vertical transportation for personnel, equipment, and extracted ore between the surface and the various underground levels. This system ensures efficient access to the workings and the timely removal of mined material, serving as the main lifeline for the mine.

30. (A) Very hard, brittle crystalline rocks.
Rotary drilling is often more efficient than percussion drilling when operating in very hard and brittle crystalline rock formations. The continuous grinding action of the rotating bit is effective at abrading these tough materials. While percussion drilling excels in certain conditions, the specialized bits and constant pressure used in rotary systems provide superior penetration and hole quality in dense, hard strata.

31. (A) Both A and R are true and R is the correct explanation of A.
Mineral dressing, or beneficiation, serves as a vital bridge between mining and metallurgy by preparing the raw ore for chemical extraction. This process focuses on physically separating valuable minerals from the surrounding waste rock, known as gangue. By increasing the concentration of the target minerals, beneficiation reduces the volume of material that must be processed in energy-intensive smelting operations.

32. (B) Sulphide ores
Froth flotation is a highly effective concentration technique primarily used for the processing of sulphide ores. This method exploits the differences in surface properties between valuable minerals and waste rock. By using specific chemical reagents, the surfaces of sulphide minerals are made water-repellent, allowing them to attach to air bubbles and float to the surface for collection as a concentrate.

33. (B) Jaw crushers and gyratory crushers are typically used as primary crushers.
Size reduction in a mineral processing plant begins with primary crushing, where large pieces of run-of-mine ore are broken down. Jaw crushers and gyratory crushers are the standard machines used for this initial stage. Subsequent stages involve secondary crushing and fine grinding. Unlike chemical processes, crushing is a purely mechanical method used to prepare ore for further mineral separation.

34. (B) 2 and 3 only
Mineral dressing utilizes various physical properties to separate valuable minerals from gangue. Specific gravity is the fundamental principle behind gravity separation techniques, while magnetic susceptibility is used in magnetic separation processes. Although hardness is an important mineral characteristic, it is primarily a factor in the efficiency of comminution processes rather than a direct mechanism for physical separation into different products.

35. (C) Separate particles into different size fractions.
Industrial screening is a mechanical process used in mineral dressing to separate a mixture of ore particles into different size fractions.

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106. (B) Records of in-situ physical properties of formations.
In the evaluation of mineral and energy deposits, well logging provides a continuous record of the in-situ physical properties of the subsurface formations. By lowering specialized instruments into a borehole, geologists can measure characteristics such as electrical resistivity, radioactivity, and acoustic velocity. This data is essential for identifying different rock layers, assessing mineral concentration, and mapping structural features deep underground.

107. (C) Shallow excavations used to expose and sample bedrock.
Pits are shallow excavations used during the early stages of mineral exploration to directly observe and sample the bedrock beneath the soil cover. They allow geologists to examine the geology and mineralization of a site at a relatively low cost. This direct observation is critical for verifying anomalies identified through indirect methods like geophysical surveys and for planning more intensive drilling.

108. (B) Provides an undisturbed sample preserving rock texture.
The primary advantage of core sampling over other drilling methods is its ability to retrieve an undisturbed, cylindrical sample of rock. This preserved sample allows geologists to examine the original rock texture, structure, and mineral orientation in detail. Such information is invaluable for accurate stratigraphic mapping and for understanding the complex geological processes that formed a mineral deposit at depth.

109. (D) Statement I is false, but Statement II is true.
Calculating ore reserves is a dynamic process that evolves throughout the life of a mining project. Initial estimates are often updated as new exploration data becomes available or as mining technology improves. Furthermore, fluctuations in market commodity prices and changes in operating costs can directly impact which portions of a deposit are considered economically mineable, causing the reserve figures to change.

110. (D) To design the marketing strategy for refined metal.
Geological exploration for commercial ore deposits focuses on identifying the location, size, and shape of mineralized zones. The primary goals include estimating the total tonnage and average grade of the ore, as well as understanding the geological setting. While developing a marketing strategy for the final product is important for the business, it is not a direct objective of geological exploration.

111. (D) The geological form and characteristics of the ore body.
The term mode of occurrence refers to the specific geological form, structure, and characteristics of a mineral deposit. It describes how the ore is situated within the host rock, such as whether it occurs as a vein, a disseminated body, or a massive layer. Understanding the mode of occurrence is essential for selecting appropriate exploration techniques and for designing efficient mining methods.

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112. (B) The level of geological knowledge and confidence.
In the United Nations Framework Classification for mineral assets, the G-axis specifically represents the level of geological knowledge and confidence associated with a deposit. This axis categorizes resources and reserves based on the intensity of exploration and the reliability of the data. Higher G-values indicate greater certainty regarding the location, size, and quality of the mineralization based on detailed investigation.

113. (C) Provides a representative sample across the ore body.
Channel sampling is considered superior to random grab sampling because it involves cutting a continuous and uniform groove across the entire width of a mineralized exposure. This systematic approach ensures that the collected material represents the actual average grade of the ore body at that location. In contrast, grab samples are often biased toward high-grade or easily accessible pieces of rock.

114. (D) Migration pathways of elements through Earth systems.
The geochemical cycle refers to the continuous migration and redistribution of chemical elements through various components of the Earth's crust, atmosphere, and hydrosphere. This cycle includes processes such as weathering, transport, deposition, and lithification. Understanding

a direct relationship between the flow rate of groundwater, the hydraulic conductivity of the material, and the hydraulic gradient. This law is essential for quantifying how water moves through aquifers and for managing groundwater resources effectively in various geological settings.

45. (A) Both Statement I and Statement II are true.
Assessing groundwater quality involves examining both physical and chemical characteristics. Physical properties include easily observable traits such as temperature, color, and turbidity, which can indicate the presence of suspended solids. Chemical characteristics are determined by the types and concentrations of dissolved minerals, gases, and organic substances. Together, these factors define the suitability of groundwater for domestic or industrial use.

46. (B) Natural seepage from rivers and lakes
Artificial recharge involves human-made interventions designed to augment the natural replenishment of groundwater. Methods include the use of spreading basins, injection wells, and check dams that trap runoff to induce infiltration. Natural seepage from rivers and lakes is a process that occurs without human assistance and is therefore considered a component of the natural hydrological cycle rather than artificial.

47. (C) It focuses exclusively on surface water, ignoring groundwater.
Watershed management is a holistic approach that integrates the conservation and management of all natural resources within the boundaries of a drainage basin. This includes soil, vegetation, and both surface and groundwater systems. The claim that it ignores groundwater is incorrect, as effective management must consider the interactions between surface runoff and the replenishment of subsurface aquifers for sustainability.

48. (B) P-4, Q-2, R-1, S-3
Hydrogeology uses specific terms to describe water-bearing systems. An aquifer is a permeable formation that stores and transmits water. An aquiclude is an impermeable layer that neither stores nor transmits water. The water table represents the upper surface of the zone of saturation. Darcy's Law provides the equation used to calculate the flow rate of water through these media.

49. (C) Its permeability and porosity.
The ability of a rock formation to function as an aquifer is primarily determined by two fundamental hydrological properties: porosity and permeability. Porosity refers to the total volume of void spaces that can store water, while permeability measures how well those spaces are interconnected to allow water flow. Together, these properties dictate the storage capacity and the transmission rate of groundwater.

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50. (C) The collection and storage of rainwater for later use.
Water harvesting is a sustainable practice that primarily involves the systematic collection and storage of rainwater for later use. By capturing runoff from rooftops or land surfaces, this technique provides a supplemental water source for irrigation and domestic needs. Additionally, water harvesting can contribute to the artificial recharge of groundwater by allowing stored water to gradually infiltrate into the soil.

51. (A) Both A and R are true and R is the correct explanation of A.
An unconfined aquifer is directly exposed to the Earth's surface and lacks an overlying impermeable layer to block the downward movement of contaminants. Consequently, pollutants from agricultural runoff or industrial spills can easily infiltrate the soil and reach the water table. This lack of a protective barrier makes unconfined systems significantly more vulnerable to surface-based contamination than confined aquifers.

52. (C) The ore can be mined and processed at a profit.
In the context of mineral exploration and mining, the term commercial grade refers to the concentration of a valuable mineral within a deposit that is high enough to allow for profitable extraction. This grade must justify the costs associated with mining, processing, transportation, and environmental management. A deposit's economic viability is fundamentally linked to whether its grade meets this commercial threshold.

53. (C) Percussion and Rotary drilling
Mineral exploration relies on various drilling technologies to investigate the subsurface and obtain geological data. Percussion drilling and rotary drilling are two of the most widely used methods. Percussion drilling uses a hammering action to shatter rock, while rotary drilling employs a rotating bit to grind or cut through formations. Both are essential for sampling and mapping potential mineral deposits at depth.

54. (D) 1, 2 and 3
Classifying ore reserves is a critical task that aids in mine planning and financial evaluation. A reserve refers to the portion of a mineral resource that has been demonstrated to be economically and technically mineable. Globally recognized systems, such as the UNFC classification, provide a standardized framework for reporting these assets, ensuring transparency and consistency in the international mining industry.

55. (D) Analysis of drilling, sampling, and assaying data.
The accurate calculation of ore reserves depends on a detailed understanding of the geometry and grade of a mineral deposit. This information is primarily gathered through intensive exploration activities, including systematic drilling programs and representative sampling. The chemical analysis of these samples, known as assaying, provides the data necessary to estimate the total tonnage and average quality of the ore.

56. (A) It is conducted on vertical or inclined stope faces.
Sampling in an underground mine differs from surface methods because it is often conducted on the vertical or inclined faces of stopes and development tunnels. These exposures provide direct access to the ore body in its three-dimensional context. Precise sampling of these faces is essential for grade control and for reconciling actual production data with the original geological resource estimates.

57. (C) The consideration of viability and technical factors.
According to the UNFC system, the primary distinction between a mineral resource and a mineral reserve lies in the degree of technical and economic assessment. While a resource represents a known concentration of minerals, a reserve is the specific portion that has been proven viable for extraction. This transition requires a thorough evaluation of mining methods, processing costs, and social factors.

58. (C) Gravity survey
Geological exploration methods are categorized as either direct or indirect. Direct methods, such as drilling, trenching, and pitting, involve physical contact with the rock or the extraction of actual samples for observation. In contrast, a gravity survey is an indirect geophysical method. It measures variations in the Earth's gravitational field to infer the presence of subsurface bodies based on density.

59. (B) Placer sampling
Evaluating a placer gold deposit in a river valley requires specialized sampling techniques tailored for unconsolidated sediments. Placer sampling focuses on recovering heavy minerals from large volumes of sand and gravel. This method often involves using specialized equipment to wash and concentrate the material, allowing geologists to determine the gold content and estimate the economic potential of the surficial deposit.

60. (A) Reduce geological uncertainty associated with the deposit.
Techniques such as core sampling and well logging are employed during exploration to gather precise data about subsurface formations. The primary objective is to reduce the geological uncertainty associated with the location, size, and quality of a mineral deposit. By increasing confidence in the geological model, these methods provide a solid foundation for investment decisions and future mine design.

61. (C) It requires corrections for elevation and topography.
A significant limitation of the gravity method in mineral exploration is its sensitivity to external factors. Precise measurements must be corrected for variations in elevation, latitude, and local topography to isolate the gravitational signal caused by subsurface density differences. These necessary corrections increase the complexity of data processing and require highly accurate surveying of station locations during the field operations.

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62. (A) It controls travel distance from source element dispersion.
In the geochemical cycle, the mobility of an element determines how far it can travel from its source during dispersion. Some elements are highly mobile in water and can create extensive secondary halos in soil and stream sediments. Understanding this mobility is crucial for geologists because it helps them trace geochemical anomalies back to the primary ore body hidden beneath the surface.

63. (C) Electrical method
The electrical method is the most suitable geophysical technique for mapping a buried body of graphite due to its high electrical conductivity. Graphite offers very low resistance to the flow of electric current compared to most surrounding host rocks. By measuring the electrical resistivity of the ground, geophysicists can identify and delineate the boundaries of such highly conductive mineralized zones.

64. (A) The diffusion and dispersion of elements.
Syngenetic and epigenetic are terms used to describe the timing of element diffusion and mineralization relative to the formation of the host rock. Syngenetic processes occur at the same time the rock is formed, while epigenetic processes happen after the rock has already crystallized or consolidated. Distinguishing between these two types is essential for understanding the origin and geometry of deposits.

65. (A) Both Statement I and Statement II are true.
Geochemical exploration relies on establishing a baseline concentration for specific elements within a given area. The background value represents the typical, normal concentration found in unmineralized material. A geochemical anomaly is a significant deviation from this background, either higher or lower, that suggests the presence of nearby mineralization. Identifying these anomalies is the primary goal of systematic soil and sediment surveys.

66. (D) The Earth's magnetic field
Geochemical exploration involves the chemical analysis of physical materials collected from the Earth. Common sampling media include rock, soil, stream sediments, and even plant material in biogeochemical surveys. While measuring the Earth's magnetic field is a fundamental part of geophysical exploration, it does not involve the chemical analysis of samples and is therefore not a part of geochemical exploration programs.

67. (A) It measures variations in the density of subsurface rocks.
The magnetic method is a geophysical technique that measures variations in the Earth's magnetic field caused by the magnetic susceptibility of subsurface minerals. It is particularly effective for locating iron ores like magnetite. While surveys can be conducted on the ground or from the air, the claim that it measures rock density is incorrect, as density is the property measured by gravity.

68. (C) P-4, Q-3, R-1, S-2
Geochemical exploration uses various concepts to locate ore. Primary dispersion happens during the formation of rocks and ore. Secondary dispersion occurs as elements redistribute in the weathering environment. A pathfinder element is a mobile indicator associated with the target ore. A geobotanical anomaly involves abnormal patterns in vegetation, such as specific growth changes, caused by the chemistry of the soil.

69. (C) Their distribution patterns can point towards hidden mineralization.
The study of trace elements is fundamental to geochemical exploration because these elements often occur in characteristic patterns around mineral deposits. Even if the primary ore metal is difficult to detect, the distribution of associated trace elements can create recognizable halos in rocks and soils. Analyzing these subtle patterns allows geologists to identify potential exploration targets that might otherwise remain hidden.

70. (A) To organize them based on the physical property measured.
Geophysical methods are primarily classified to organize them according to the specific physical property they measure. This classification helps geologists and geophysicists select the most appropriate technique for a given exploration target. For example, methods are grouped based on whether they detect contrasts in density, magnetic susceptibility, electrical conductivity, or seismic wave velocity, ensuring the most effective application in the field.

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This is achieved by passing the material over a surface with specific openings. Sizing is crucial because subsequent stages, such as grinding or concentration, operate most efficiently when the feed material falls within a specific and uniform size range.

36. (B) Gravity separation
Gravity separation is a mineral processing technique that relies on the differences in specific gravity between various minerals. In a fluid medium, heavier minerals settle more quickly or follow different paths than lighter gangue particles. This principle is applied in equipment such as jigs, shaking tables, and spiral concentrators to produce a high-grade concentrate from the raw crushed ore.

37. (D) Lead and Zinc
The Zawar Mines in Rajasthan hold great historical and archaeological significance in India due to their long history of mineral production. These mines are particularly famous for the ancient extraction and smelting of lead and zinc ores. Evidence of sophisticated metallurgical techniques, such as the use of retorts for zinc distillation, showcases the advanced knowledge possessed by ancient Indian miners.

38. (B) Gravity separation
Heavy Medium Separation, or dense media separation, is a specialized form of gravity separation. It involves using a fluid with a specific density that is between the densities of the minerals to be separated. In this medium, lighter particles float while heavier particles sink. This highly effective process allows for the precise separation of minerals based on their physical density.

39. (A) Both Statement I and Statement II are true.
Size reduction in mineral processing typically occurs in multiple stages to ensure efficiency. A primary crusher is designed to accept large, unsorted run-of-mine ore directly from the mining site. The output from this first stage is then fed into a secondary crusher, which further reduces the particle size. This sequential approach prepares the material for the final fine grinding stage.

40. (B) III, II, I
In a typical mineral dressing plant, the comminution process follows a logical sequence of size reduction to liberate minerals. It begins with primary crushing to break down large rocks, followed by secondary crushing for further reduction. The final stage is the grinding mill, which reduces the material to a fine powder. This sequence ensures that each machine operates at its optimal capacity.

41. (B) The movement of water on, above, and below the Earth's surface.
The hydrological cycle represents the continuous and global movement of water across various Earth systems. This process includes the circulation of water between the oceans, the atmosphere, and the land surface, as well as its movement through subsurface soil and rock layers. Driven primarily by solar energy and gravity, the cycle encompasses precipitation, evaporation, infiltration, and surface runoff.

42. (A) Precipitation that infiltrates the ground surface.
While groundwater can originate from various sources, the vast majority comes from meteoric water. This process begins with precipitation, such as rain or snow, which falls onto the Earth's surface. A portion of this water infiltrates the soil and percolates downward through pore spaces and fractures until it reaches the zone of saturation, thereby replenishing the groundwater supply.

43. (C) A rock formation that can store and transmit groundwater.
An aquifer is a geological formation, group of formations, or part of a formation that is sufficiently porous and permeable to store and transmit significant quantities of groundwater. These formations can provide a usable supply of water for various purposes. Common examples of aquifers include layers of sand, gravel, and certain types of fractured rock that allow for water movement.

44. (B) Rate of flow of groundwater through a porous medium.
Darcy's Law is a fundamental mathematical principle in hydrogeology that describes the flow of fluids through porous media. It establishes

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a stable working platform for the subsequent mining stages.

80. (D) III, II, I
The development of mining typically follows a logical sequence based on the depth of the deposit. Alluvial mining is the simplest form, targeting unconsolidated surface materials. As technology advances, open-cast mining is used for larger deposits near the surface. Finally, underground stoping methods are employed for deep mineralized zones that cannot be economically or safely accessed from the surface environment.

81. (A) Both Statement I and Statement II are true.
Drilling methods are classified based on the mechanical action used to penetrate rock. Percussion drilling operates by repeatedly hammering and chipping the rock surface to break it into fragments. Rotary drilling, however, uses a rotating bit to grind or cut through the rock mass. Both techniques are essential in exploration, with the choice depending on the hardness and nature of the formations.

82. (D) In-situ leaching
Traditional mining involves the physical excavation and removal of rock from the Earth. Methods like alluvial mining, open-cast mining, and various underground stoping techniques are standard industrial practices. In-situ leaching is a different process that involves dissolving minerals in place using chemical solutions. While it is an extraction technique, it is often categorized separately from mechanical rock excavation methods.

83. (C) All underground mining methods are classified as stoping methods.
Mining methods are broadly classified into surface and underground categories, with the choice depending on factors like depth and rock strength. While many underground hard rock techniques are called stoping methods, the claim that all underground mining falls into this category is incorrect. For example, coal mining uses distinct systems like longwall or room and pillar, which are not usually termed stoping.

84. (C) To serve as permanent roof support for workings.
In the room and pillar mining method, large sections of the ore or coal are left in place as the extraction progresses. The primary function of these remaining pillars is to provide permanent structural support for the roof of the underground workings. This prevents the collapse of the overlying rock strata, ensuring the safety of the miners and the integrity of the mine.

85. (B) The winding system
The winding system is the critical component of a mining operation responsible for the vertical movement of people, equipment, and materials between the surface and underground levels. Utilizing hoists, cages, and skips, this system serves as the primary transportation link through the mine shaft. It is distinct from the haulage system, which handles the horizontal transport of materials within the mine.

86. (B) To physically separate valuable minerals from gangue.
Mineral dressing, also known as ore beneficiation, is the process of physically separating valuable minerals from the unwanted waste rock, or gangue. The primary goal is to increase the concentration of the target minerals to produce a high-grade product suitable for metallurgical processing. This concentration reduces the volume of material that must be transported and treated in expensive smelting facilities.

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87. (B) Grinding mill (e.g., ball mill, rod mill)
A grinding mill, such as a ball mill or rod mill, is a specialized piece of equipment designed for the final stage of size reduction in mineral dressing. Unlike crushers that break large rocks, these mills use grinding media to reduce ore to a very fine, powder-like consistency. This fine grinding is essential for liberating individual mineral grains from the surrounding gangue.

88. (C) Magnetic susceptibility
Magnetic separation is a mineral processing technique that exploits the differences in magnetic susceptibility among minerals. When a mixture of crushed ore passes through a magnetic field, minerals with high magnetic attraction are separated from non-magnetic gangue. This method is highly effective for concentrating iron-

71. (A) Both A and R are true and R is the correct explanation of A.
The seismic method is the dominant geophysical tool in the petroleum industry for exploring subsurface geological structures. By producing high-resolution images of sedimentary layers, it allows geophysicists to identify features like folds and faults that can trap oil and gas. Because it provides a detailed picture of the deep subsurface geometry, it is indispensable for selecting successful drilling locations for hydrocarbons.

72. (A) The type of dispersion pattern (primary or secondary).
Selecting the most appropriate sampling technique in geochemical exploration depends heavily on the type of dispersion pattern geologists expect to find. Primary dispersion halos in solid bedrock require rock chip sampling. In contrast, secondary dispersion patterns resulting from weathering are better identified through soil or stream sediment sampling. The choice is driven by the environmental history and the nature of the target.

73. (C) Were introduced into the host rock after its formation.
Epigenetic diffusion refers to the process where chemical elements are introduced into a host rock after it has already formed and solidified. This typically occurs when hydrothermal fluids or mineralizing solutions migrate through fractures or pore spaces in the pre-existing rock. This process is distinct from syngenetic diffusion, where elements are incorporated into the rock at the same time it forms.

74. (B) 2 and 3 only
Geophysical exploration is an indirect method that relies on detecting contrasts in the physical properties of rocks, such as magnetism, density, and conductivity. The four main classes of these methods include electrical, magnetic, gravity, and seismic surveys. While these techniques identify anomalies, they do not always guarantee the presence of ore, as other geological features can produce similar physical signals.

75. (B) A lateral variation in the density of subsurface rocks.
A gravity anomaly detected during a geophysical survey is primarily caused by lateral variations in the density of subsurface rocks and minerals. When a dense body of ore or a low-density salt dome exists beneath the surface, it alters the local gravitational pull. By measuring these minute differences, geophysicists can map the distribution of materials with different densities at depth.

76. (B) Vocabulary describing operations, equipment, and features.
Mining terminology refers to the specialized vocabulary used by professionals in the industry to describe various operations, equipment, and geological features. This technical language ensures clear communication during complex activities like drilling, blasting, and extraction. Understanding terms such as shaft, stope, and haulage is essential for anyone involved in the planning, management, and execution of mining projects and related geological studies.

77. (D) Open-cast is from surface; underground uses shafts and tunnels.
The fundamental difference between open-cast and underground mining lies in the method of accessing the ore body. Open-cast mining, also known as surface mining, involves removing the overlying waste rock to extract minerals directly from the surface. In contrast, underground mining requires the construction of shafts and tunnels to reach and extract ore deposits located deep within the Earth's crust.

78. (A) High coal recovery achieved by roof collapse.
Longwall mining is a highly productive underground coal extraction method characterized by the use of a mechanical shearer that moves across a long face of coal. As the machine advances and the coal is removed, the roof behind the support system is allowed to collapse in a controlled manner. This technique achieves very high resource recovery compared to other methods.

79. (B) Cut-and-fill stoping
In underground mining, weak ground conditions often require immediate structural support during the extraction process. Cut-and-fill stoping is a method where the excavated area is filled with waste rock or other materials after each layer of ore is removed. This fill provides essential support for the stope walls and creates

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air and water, as well as the zone of saturation, where all openings are filled with groundwater. It is a vital component of the hydrological cycle and a primary source of freshwater.

98. (B) P-2, Q-3, R-1, S-4
Different forms of water are characterized by their location and origin. Groundwater in a phreatic aquifer is subsurface water replenished by precipitation. A mountain lake is a body of surface water. An ice cap represents a solid form of surface water. Connate water is a specialized type of subsurface water that was trapped within sediments during their original deposition process.

99. (B) An aquitard
A geological formation that has high porosity but very low permeability is known as an aquitard. While such a formation can store significant amounts of water within its pore spaces, the lack of interconnectedness prevents the water from moving freely through it. Clay is a common example of an aquitard, as it can hold water but transmits it very slowly.

100. (D) The presence of bacteria, such as coliforms.
Groundwater quality is assessed using various physical, chemical, and biological parameters. Biological characteristics specifically refer to the presence of living organisms within the water supply. Testing for bacteria, such as coliforms, is a critical part of this assessment, as their presence often indicates contamination from sewage or surface runoff, posing a significant health risk to those using the water.

101. (A) Both A and R are true and R is the correct explanation of A.
Darcy's Law is specifically designed for the analysis of laminar groundwater flow, where water moves smoothly through porous media. In most natural aquifers, flow velocities are low enough for this law to be valid. However, in situations where velocities are exceptionally high, the flow becomes turbulent. In these cases, the linear relationship between velocity and gradient fails, making Darcy's Law inapplicable.

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102. (A) To preserve ecological functions and biodiversity.
The primary objective of wetland management is to preserve the critical ecological functions and rich biodiversity associated with these unique environments. Wetlands play a vital role in water purification, flood control, and providing habitats for numerous species. Effective management focuses on protecting these areas from drainage, pollution, and unsustainable development to ensure they continue to provide these essential ecosystem services.

103. (A) Treats the entire drainage area as a single unit.
The concept of watershed management is based on treating the entire drainage area as a single, integrated unit for planning and conservation. This approach recognizes that all land and water resources within a watershed are interconnected. By managing the basin as a whole, it is possible to balance various needs, such as agriculture, forestry, and water supply, while ensuring long-term sustainability.

104. (D) 1, 2 and 3
Groundwater recharge occurs through both natural and artificial processes. Natural recharge is primarily driven by the infiltration of precipitation and seepage from surface water bodies. Artificial recharge involves human interventions, such as the construction of check dams or injection wells, to intentionally augment the replenishment of aquifers. Both processes are essential for maintaining sustainable groundwater levels and meeting water demands.

105. (C) An aquifer is sandwiched between two impermeable layers (aquicludes) is known as:
An aquifer that is sandwiched between two impermeable layers of rock or sediment, known as aquicludes, is classified as a confined aquifer. Because the water is trapped under pressure, it often rises above the top of the formation when a well is drilled into it. This type of system is generally better protected from surface-based contamination than unconfined or perched aquifers.

bearing minerals like magnetite and for removing magnetic impurities from various industrial mineral products and ores.

89. (C) Magnetic separation
To separate magnetite from quartz, a mineral processing plant would utilize magnetic separation. Magnetite is a strongly magnetic iron oxide, whereas quartz is non-magnetic. By passing the crushed mixture through a magnetic separator, the magnetite particles are attracted and held by the magnetic field while the quartz continues on its path. This provides a clean and efficient separation based on magnetism.

90. (C) Statement I is true, but Statement II is false.
Froth flotation is a sophisticated mineral separation technique that utilizes the differing surface properties of minerals, specifically their wettability. By using chemical reagents, certain minerals are made water-repellent, allowing them to attach to air bubbles and float. Although it involves sinking and floating, it is not a gravity-based method, as the separation is driven by surface chemistry rather than density.

91. (C) It reduces crushed ore to fine particles to liberate minerals.
In the mineral dressing circuit, the grinding mill plays a crucial role by reducing crushed ore into extremely fine particles. This process is necessary to achieve liberation, where the individual grains of valuable minerals are physically freed from the surrounding waste rock. Once liberated, the minerals can then be effectively separated using techniques like flotation, magnetic separation, or gravity concentration.

92. (D) Radioactivity of the mineral.
Mineral dressing focuses on physical separation techniques based on specific mineral properties. Density is utilized in gravity separation, magnetic susceptibility is used in magnetic separation, and surface wettability is the basis for froth flotation. While some minerals are radioactive, this property is typically used for detection and exploration rather than as a primary mechanism for industrial separation in a processing plant.

93. (B) It shows ancient mining evidence for lead and zinc.
The Zawar Mines in Rajasthan are globally recognized for providing extensive evidence of ancient mining and metallurgical activities. Archaeological findings at the site confirm that lead and zinc were extracted and processed there hundreds of years ago. These discoveries include remains of sophisticated distillation retorts, demonstrating that ancient Indian metallurgists had mastered the difficult process of producing metallic zinc.

94. (C) Primary handles coarse ore; secondary reduces primary output.
The distinction between primary and secondary crushers lies in their position and function within the size reduction circuit. A primary crusher is designed to handle large, coarse pieces of run-of-mine ore as they arrive from the mine. The output from this stage is then processed by a secondary crusher, which further reduces the material to a size suitable for the grinding mills.

95. (A) Ability to float in a liquid of intermediate density.
Heavy medium separation is a gravity-based process where mineral particles are separated based on their ability to float or sink in a liquid of intermediate density. The medium's density is carefully controlled so that lighter waste material floats while the heavier valuable minerals sink. This method allows for a very precise separation of minerals with different physical densities in large quantities.

96. (C) Oceans
When considering the distribution of water on the Earth's surface, the vast majority is found in the oceans. These massive saline bodies contain approximately ninety-seven percent of all the planet's water. The remaining small percentage is distributed among glaciers, ice caps, groundwater, and surface water bodies like rivers and lakes, with the oceans being the most significant reservoir by far.

97. (B) Below the ground surface.
The term subsurface water is a broad classification that encompasses all water occurring beneath the Earth's surface. This includes water in the unsaturated zone, where pore spaces contain both

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these migration pathways is essential in mineral exploration, as it explains how elements are concentrated into ore deposits and later dispersed into the surrounding environment.

115. (A) The pathfinder forms a broader dispersion halo than the target.
The fundamental principle of using pathfinder elements in geochemical exploration is that they form a broader and more easily detectable dispersion halo than the target ore element. By identifying these associated elements in soil or stream sediments, geologists can locate potential mineral deposits that might otherwise be missed. This method provides a larger and more reliable target during initial exploration phases.

116. (C) Statement I is true, but Statement II is false.
The seismic reflection method is a powerful geophysical tool based on measuring the travel times of sound waves that bounce off subsurface interfaces. This allows for detailed mapping of geological layers. However, the gravity method does not measure electrical resistivity; instead, it detects variations in the Earth's gravitational field caused by differences in the density of various subsurface rock formations.

117. (D) Weathering and redistribution of a primary ore body.
Secondary dispersion halos are created when a primary ore body is exposed at or near the surface and undergoes weathering. Environmental processes like erosion and the action of groundwater redistribute the mineral elements into the surrounding soil, stream sediments, and vegetation. These halos are often much larger than the original deposit, making them excellent targets for systematic geochemical exploration programs.

118. (A) Gravity method
Passive geophysical methods are those that measure a naturally occurring field of the Earth without the need for an artificial energy source. The gravity method is a prime example, as it detects minute variations in the Earth's natural gravitational pull caused by density differences. In contrast, active methods like seismic reflection or electrical resistivity require the introduction of energy into the subsurface.

119. (C) A geobotanical anomaly indicating potential mineralization.
A geobotanical anomaly occurs when the presence, growth patterns, or chemical composition of vegetation is altered by underlying soil chemistry. Observing stunted tree growth or specialized species like copper moss, which thrive in metal-rich environments, can provide geologists with critical clues. These botanical indicators often point toward hidden mineralization, serving as a cost-effective tool for identifying potential targets during early exploration.

120. (C) II, III, I
Geochemical dispersion typically follows a logical sequence from the point of origin. It begins with the formation of a primary dispersion halo within the solid rock around the ore deposit. As the deposit is exposed to the surface, it undergoes weathering. Finally, the weathered material is redistributed into the environment, creating a secondary dispersion halo in the surrounding soil and sediments.

121. (D) The magnetic susceptibility of the element.
The mobility of an element in the surficial geochemical environment is influenced by various physicochemical factors. The pH and Eh of the surrounding water, along with the presence of organic matter, significantly control how easily an element can be leached and transported. However, the magnetic susceptibility of an element has no impact on its chemical mobility during weathering and environmental dispersion.

122. (B) Faster and smoother deep penetration in softer rocks.
In deep sedimentary basins, rotary drilling is often preferred over percussion drilling due to its faster and smoother penetration in relatively softer rock formations. The continuous rotating action of the bit, combined with the use of drilling fluids to remove cuttings and stabilize the hole, allows for efficient deep drilling. This method is particularly effective for reaching targets at great depths.

123. (C) Underground hard rock mining
Stoping is a specialized term used exclusively to describe the systematic excavation of ore in underground hard rock mining. It refers to the

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systematic extraction of coal while managing the pressure of the overlying rock layers. Longwall mining is often preferred for its high production rates and nearly complete recovery of the resource.

160. (B) A significant amount of the resource is left behind.
A major disadvantage of the room and pillar mining method compared to longwall mining is that a significant amount of the mineral resource is permanently left behind. These remaining pillars are necessary to provide structural support for the roof of the workings. In contrast, longwall mining allows for much higher recovery rates by systematically collapsing the roof after the coal is extracted.

161. (A) Both A and R are true and R is the correct explanation of A.
Cut-and-fill stoping is a specialized underground mining method where the void created by ore extraction is immediately filled with waste rock or other materials. This practice is essential for providing structural support to the stope walls and preventing ground collapse. Furthermore, the layer of fill serves as a stable and safe working platform for miners as they advance upward.

162. (A) Achieve separation without the use of chemical reagents.
Utilizing physical properties like density and magnetism allows mineral dressing plants to achieve effective separation of valuable minerals from gangue without always relying on complex chemical reagents. These physical methods are often more cost-effective and environmentally friendly. By exploiting the inherent natural characteristics of the minerals, geoprocessors can concentrate the ore efficiently while maintaining the chemical integrity of the products.

163. (A) Size reduction, including crushing and grinding.
The term comminution in mineral dressing encompasses the overall process of reducing the size of raw ore to liberate valuable minerals. This process typically occurs in multiple stages, beginning with coarse crushing and followed by fine grinding. Comminution is the most energy-intensive part of mineral processing but is absolutely necessary to prepare the ore for subsequent separation and concentration techniques.

164. (A) 1 only
Heavy medium separation is a specialized type of gravity separation that uses a fluid of specific density to sort minerals. However, froth flotation is based on surface chemistry and wettability rather than density. Additionally, magnetic separation is only effective for minerals with specific magnetic properties. Therefore, of the statements provided, only the first one regarding heavy medium separation is correct.

165. (A) Repel water and attach to air bubbles.
In the froth flotation process, particles classified as hydrophobic are those that naturally repel water or have been chemically treated to do so. These water-repellent particles prefer to attach themselves to the air bubbles introduced into the mineral slurry. As the bubbles rise to the surface, they carry the hydrophobic valuable minerals into a froth layer for efficient collection.

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166. (B) High-capacity crushing of large, hard rock.
A primary gyratory crusher is exceptionally well-suited for high-capacity operations that require the initial breaking of large and hard pieces of rock. Its robust design allows it to process massive volumes of run-of-mine ore continuously. This makes it a preferred choice for large-scale mining operations where the primary goal is to reduce boulders to a size manageable for secondary crushing.

167. (C) Porosity and permeability.
In the field of hydrogeology, the most critical physical characteristics of a rock formation are its porosity and permeability. Porosity determines the total storage capacity for groundwater within the pore spaces and fractures. Permeability measures the ability of those spaces to transmit water freely. Together, these two properties define whether a geological formation can act as a productive and reliable aquifer.

168. (D) Lithification
The hydrological cycle involves the continuous movement of water through processes like evaporation, precipitation, and infiltration. These stages describe how water circulates between the atmosphere, surface, and subsurface.

or are influenced differently by centrifugal and frictional forces than lighter particles. This allows for the effective separation of valuable minerals from the less dense gangue.

133. (C) To liberate individual mineral grains from gangue.
The primary role of a grinding mill is to reduce the size of crushed ore to a point where the individual grains of valuable minerals are physically separated, or liberated, from the surrounding gangue. This liberation is essential for subsequent concentration processes like froth flotation. Only when the mineral grains are free can chemical reagents effectively target and float the valuable components.

134. (A) 1 and 2 only
Mineral dressing is fundamentally a process of physical separation designed to increase mineral concentration and reduce the volume of material requiring further treatment. While crushers and mills are both used for size reduction, their roles are distinct. Crushers are typically used for the initial coarse breaking of large rocks, whereas grinding mills are employed for the final stage of fine grinding.

135. (A) The mining and smelting of lead-zinc ores.
The archaeological evidence found at the Zawar Mines in Rajasthan demonstrates that ancient Indian miners possessed advanced knowledge of lead and zinc production. The presence of numerous old workings and sophisticated distillation furnaces indicates a high level of expertise in both mining and extractive metallurgy. This site serves as a remarkable testament to the technical capabilities of ancient Indian metallurgists.

136. (B) Surface exists on land; subsurface exists in pore spaces.
The most significant difference between surface water and subsurface water is their location within the hydrological system. Surface water exists openly on the land in the form of rivers, lakes, and oceans. Subsurface water, in contrast, occurs beneath the ground surface, filling the pore spaces, fractures, and voids within various soil layers and geological formations throughout the zone of saturation.

137. (C) Energy from the sun.
The hydrological cycle is a massive global system primarily driven by energy from the sun. Solar radiation causes water to evaporate from the oceans and land surfaces, lifting it into the atmosphere. This energy, combined with the Earth's gravity, powers the continuous circulation of water through evaporation, condensation, and precipitation, ensuring the constant movement of water between different Earth reservoirs.

138. (D) Ways water is stored within subsurface formations.
In the context of hydrogeology, the term occurrence refers to the specific ways in which water is stored and distributed within various subsurface geological formations. This includes understanding the depth of the water table, the thickness of saturated zones, and the type of formations involved. Studying the occurrence of groundwater is essential for identifying potential aquifers and managing regional water resources effectively.

139. (D) Porosity
Porosity is a fundamental physical property of rocks and sediments, defined as the total volume of void space within the material expressed as a percentage of its total volume. These voids can include pores, fractures, and vesicles that have the potential to store fluids. High porosity is a necessary condition for a geological formation to serve as an effective groundwater reservoir.

140. (C) Physical
Turbidity is a physical characteristic of water that measures the cloudiness or haziness caused by the presence of suspended particles. In groundwater, high turbidity often indicates the presence of silt, clay, or organic matter. Monitoring this physical property is essential for assessing water quality and for determining the effectiveness of natural filtration processes as water moves through subsurface soil and rock.

141. (C) Artificial recharge of groundwater.
The construction of percolation tanks and check dams is a primary strategy for the artificial recharge of groundwater. These structures are designed to slow down the speed of surface runoff during rainfall, allowing more time for the water to infiltrate into the soil. By increasing the

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process of creating voids, or stopes, as the valuable mineral is removed between different levels or development tunnels. This term is not applied to surface operations like open-cast mining or to the extraction of unconsolidated placer deposits.

124. (D) It processes unconsolidated sediments like sand and gravel.
A key characteristic of alluvial mining is that it targets and processes unconsolidated sediments such as sand, gravel, and silt. These deposits, often found in ancient or modern riverbeds, contain heavy minerals that have been concentrated by the natural action of water. Unlike hard rock mining, alluvial operations typically rely on gravity-based separation techniques rather than extensive drilling and blasting.

125. (B) Both Statement I and Statement II are false.
In mining operations, haulage and winding refer to distinct transportation systems. Haulage specifically describes the horizontal movement of ore and materials within the mine tunnels or on the surface. Winding, on the other hand, refers to the vertical hoisting of personnel and materials through a shaft. The provided statements are incorrect because they have reversed the definitions of these two essential processes.

126. (B) Open-cast mining
Open-cast mining is characterized by very high production rates and relatively low operating costs per unit of material moved. This makes it the most economical method for extracting large, low-grade ore bodies located close to the surface. By removing the overburden and creating a large open pit, miners can use massive equipment to extract the mineralized material efficiently at scale.

127. (D) The strength of the ore and surrounding wall rock.
The selection of a specific stoping method in underground mining is primarily determined by the geomechanical properties of the ore body and the surrounding host rock. Factors such as the strength and stability of the rock mass dictate whether the excavated stope can remain open, requires immediate filling, or must be supported by pillars to prevent collapse during the extraction process.

128. (B) P-4, Q-1, R-2, S-3
Mining methods are chosen based on the deposit type. Open-cast mining is used for large, near-surface disseminated bodies. Alluvial mining targets gold in river gravels. Room and pillar mining is standard for flat-lying coal or salt beds. Cut-and-fill stoping is suitable for steeply dipping veins where weak wall rocks require immediate support to maintain structural integrity during the extraction.

129. (C) Primary crushing
The primary function of a jaw crusher in a mineral dressing plant is to perform the initial stage of size reduction. It is designed to accept large, unsorted pieces of run-of-mine ore and break them down into smaller fragments. This primary crushing stage is essential for preparing the material for further reduction in secondary crushers and eventual liberation in grinding mills.

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130. (D) Separate particles based on differences in their size.
Industrial screening is a mechanical separation process used in mineral processing to sort particles into different size fractions. By passing the crushed ore over a vibrating or rotating surface with specific opening sizes, the material is divided into various categories. This sizing is critical for ensuring that subsequent processing stages receive a feed material that meets their specific operating requirements.

131. (A) Both A and R are true and R is the correct explanation of A.
Froth flotation is an exceptionally effective method for concentrating finely disseminated sulphide ores. It works by exploiting the surface chemistry of minerals, where chemical reagents are used to make the target sulphide grains water-repellent. These hydrophobic particles then attach to air bubbles and float to the surface, allowing them to be separated from the hydrophilic waste rock that remains submerged.

132. (B) Specific gravity
Equipment such as spiral concentrators and shaking tables are fundamental tools in gravity separation. These devices exploit the differences in specific gravity between minerals. In a flowing film of water, heavier particles settle more quickly

of the bit efficiently grinds through the material. When combined with modern drilling fluids, this method allows for rapid progress in large-scale exploration programs, enabling geologists to cover more ground in less time.

151. (D) A is false but R is true.
The magnetic geophysical method relies on detecting variations in magnetic susceptibility. It is highly effective for finding minerals like magnetite but would be ineffective for massive sulfide deposits that lack magnetic minerals. The assertion is false because the method requires a magnetic contrast to function. The reason correctly explains that without such properties, the technique cannot detect the target mineralized body.

152. (B) Occurs in very small, but significant quantities.
In the context of geochemical exploration, a trace element is defined as an element that occurs in extremely small but still significant and measurable quantities within rocks and soils. Despite their low abundance, the distribution and concentration patterns of these elements can provide geologists with critical information about the geological processes that formed or altered a mineral deposit over time.

153. (A) Represents a composite sample of upstream geology.
Stream sediment sampling is a powerful reconnaissance tool in geochemical exploration because the sediment acts as a natural composite sample of the entire upstream drainage area. As rocks weather and erode, they release minerals into the stream system. By analyzing a single sediment sample, geologists can identify chemical anomalies that originate from potentially mineralized zones located anywhere within the upstream watershed.

154. (C) 1 and 3 only
Geobotanical exploration involves the systematic study of vegetation to find clues about underlying geological features and mineralization. Certain indicator plants are particularly useful as they thrive in soils with elevated metal concentrations. Although it is a scientific exploration technique, it is categorized as a biological or geochemical approach rather than a geophysical method, which would instead measure physical rock properties.

155. (D) Magnetic method
To distinguish between a low-density salt dome and a high-density body of massive sulfides, gravity and seismic methods are highly effective due to the significant contrasts in density and wave velocity. However, the magnetic method would be the least effective choice in this scenario if neither the salt nor the sulfides possess significant magnetic susceptibility, as it only measures magnetic properties.

156. (B) The geological nature of the formation to be drilled.
The choice between percussion and rotary drilling is most fundamentally based on the geological nature of the formations being drilled. Percussion drilling excels in hard, brittle rocks where a hammering action is effective. Rotary drilling, however, is often more efficient in softer or deeply buried strata where a continuous cutting or grinding action provides better penetration and more consistent results.

157. (C) A shaft
In mining terminology, a shaft is the primary vertical or near-vertical opening that connects the surface to the various underground workings. It serves as the main conduit for transporting personnel, equipment, materials, and extracted ore. The shaft also plays a critical role in mine ventilation, allowing for the circulation of fresh air into the deep levels of the mining operation.

158. (A) P-2, Q-4, R-1, S-3
Mining involves several sequential operations with specific functions. Drilling creates precise holes to accommodate explosives. Blasting utilizes those explosives to fracture the rock mass. Haulage is the process of transporting the broken rock horizontally to a collection point. Stoping is the final step where the ore body is systematically excavated between levels to extract the valuable mineral resource.

159. (C) Longwall or Room and pillar mining
For a thick, flat-lying coal seam located at a depth of several hundred meters, underground mining methods like longwall or room and pillar are most appropriate. These techniques allow for the

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amount of water reaching the subsurface, these measures help replenish depleted aquifers and sustain wells.

142. (A) Provide water purification and flood control services.
Wetland management is crucial because these unique ecosystems provide vital environmental services, including natural water purification and significant flood control. Wetlands act as sponges that absorb excess rainfall, reducing the impact of floods downstream. They also filter pollutants from water as it moves through the system, maintaining regional water quality and supporting a wide variety of plant and animal species.

143. (B) Natural replenishment by infiltration of precipitation.
Natural recharge is the process by which groundwater is replenished through the natural infiltration of water from the surface. This occurs primarily when precipitation, such as rain or melting snow, soaks into the ground and percolates downward to the water table. Seepage from rivers, streams, and lakes also contributes to this natural replenishment, maintaining the balance within various subsurface water-bearing formations.

144. (B) Hydraulic gradient.
According to Darcy's Law, the rate at which groundwater flows through a porous medium is directly proportional to the hydraulic gradient. This gradient represents the change in hydraulic head over a given distance, essentially describing the pressure or slope that drives the water movement. Understanding this relationship is fundamental for hydrogeologists to predict the direction and speed of groundwater flow.

145. (A) An overlying impermeable layer.
A confined aquifer is distinguished from an unconfined aquifer by the presence of an overlying impermeable layer, known as an aquiclude or aquitard. This layer restricts the upward movement of water and traps it under pressure within the formation. In contrast, an unconfined aquifer is open to the surface and its upper boundary is defined by the free-moving water table.

146. (A) Systematic and unbiased coverage for a survey.
Using a systematic exploratory grid ensures that a geological or geochemical survey achieves unbiased and thorough coverage of a target area. By collecting data and samples at regular, predetermined intervals, geologists can create a reliable map of the subsurface and identify any mineralized zones. This organized approach minimizes the risk of missing localized anomalies that could represent significant ore deposits.

147. (D) Air-quality sampling
Mineral exploration involves various types of sampling to evaluate geological formations. Core sampling, channel sampling, and placer sampling are all direct methods used to obtain physical pieces of rock or sediment for analysis. While air-quality sampling is a legitimate environmental monitoring technique, it is not used to evaluate the mineral potential or geological characteristics of a subsurface mineral deposit.

148. (A) Increasing levels of geological confidence.
Classifying ore reserves into categories like proved, probable, and possible reflects the increasing levels of geological confidence associated with the deposit. These categories are determined by the density of exploration data, such as drilling and sampling results. Proved reserves have the highest certainty, while possible reserves represent areas where the mineralization is expected but has not been definitively confirmed by extensive investigation.

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149. (C) Assaying
The process of taking physical samples from a drilling or exploration program and determining their mineral or metal content in a specialized laboratory is called assaying. This quantitative chemical analysis is essential for identifying the grade and value of a potential ore body. The data generated through assaying is a primary requirement for the economic evaluation and planning of mining operations.

150. (C) Relatively fast penetration in softer formations.
A significant advantage of rotary drilling in mineral exploration is its relatively fast rate of penetration, particularly in softer or less abrasive rock formations. The continuous rotating action

Lithification, however, is a geological process where loose sediments are compacted and cemented over time to form solid sedimentary rock. It is part of the rock cycle rather than the hydrological cycle.

169. (A) It must store and transmit water in usable quantities.
To be classified as an aquifer, a rock formation must meet two fundamental requirements: it must be able to store water and transmit it in usable quantities. This depends on the formation having sufficient porosity for storage and enough permeability for flow. Aquifers are essential natural resources that provide reliable water supplies for domestic, agricultural, and industrial needs across the world.

170. (C) Statement I is true, but Statement II is false.
Darcy's Law provides a critical mathematical description of how groundwater flows through porous media. It is a fundamental principle in hydrogeology. However, the law states that the flow velocity is directly proportional to the hydraulic conductivity, not inversely proportional. This means that as the conductivity of a material increases, the rate at which water can move through it also increases.

171. (A) Contamination from agricultural runoff or sewage.
The detection of high levels of nitrates and coliform bacteria in a shallow well is a strong indicator of environmental contamination. These substances typically enter the groundwater system from surface sources such as agricultural fertilizers, animal waste, or leaking sewage systems. Their presence indicates that the well is not adequately protected from surface infiltration and that the water may be unsafe.

172. (A) Slow down runoff, reduce erosion, and increase recharge.
As part of integrated watershed management, constructing check dams and gully plugs aims to slow the velocity of surface runoff. By reducing the speed of flowing water, these structures minimize soil erosion and allow more time for water to infiltrate the ground. This process significantly increases the artificial recharge of groundwater, helping to replenish aquifers and improve water availability.

173. (B) Any man-made facility that adds water to an aquifer.
Artificial recharge of groundwater refers to any man-made facility or engineering intervention designed to increase the amount of water entering an aquifer. These systems augment the natural replenishment process by capturing and directing surface water, such as treated wastewater or storm runoff, into the subsurface. Common methods include spreading basins, injection wells, and various structures that induce increased soil infiltration.

174. (B) Preserving the hydrological and ecological functions.
A key component of wetland management is the preservation of the unique hydrological and ecological functions that these areas perform. This involves maintaining the natural water balance and protecting the diverse habitats that support local wildlife. Effective management strategies aim to prevent the loss of wetlands to development and pollution, ensuring they continue to provide these essential ecosystem services.

175. (B) Water table
In an unconfined aquifer, the upper surface of the zone of saturation is specifically called the water table. Below this level, all the pore spaces and fractures in the soil and rock are completely filled with groundwater. The water table represents the boundary where the fluid pressure in the subsurface is equal to the atmospheric pressure at the Earth's surface.

176. (B) Disseminated mineralization with a felsic intrusion.
Porphyry copper deposits are characterized by a specific mode of occurrence where valuable minerals are disseminated throughout a large volume of host rock. This mineralization is genetically and spatially associated with felsic to intermediate igneous intrusions. Because the ore is spread out rather than concentrated in a single vein, these deposits are typically mined on a massive scale using open-pit methods.

177. (A) A physical cylinder of rock.
The primary and most valuable output of core sampling during exploration drilling is a continuous, physical cylinder of rock recovered

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from the subsurface. This core provides an intact sample of the geological formations, allowing geologists to directly observe mineral content, rock structure, and textures. Such detailed information is essential for accurate geological modeling and for determining the grade of an ore body.

178. (B) The Economic and social viability.
In the United Nations Framework Classification system, the E-axis represents the economic and social viability of a mineral project. This axis evaluates whether the extraction and sale of the mineral are profitable under current market conditions and whether the project meets necessary legal and environmental standards. It is a critical factor in determining whether a resource can be classified as a reserve.

179. (D) Cutting a continuous horizontal channel across the vein.
When evaluating a narrow, vertical vein of gold ore, cutting a continuous horizontal channel across the entire width of the vein provides the most reliable grade estimate. This systematic sampling method ensures that the sample accurately represents the variations in mineral concentration across the exposure. Random grab samples or drilling parallel to the vein would introduce significant bias and yield unreliable data.

180. (D) III, I, II
Mineral exploration follows a logical progression starting with regional geological mapping and prospecting to identify promising areas. Once a target is defined, intensive site-specific work begins with core drilling and systematic sampling to gather detailed subsurface data. Finally, all the collected information on volume, tonnage, and mineral grade is used to perform the final calculation of ore reserves for economic assessment.

181. (A) Provide a reference system for locating and recording data.
The primary purpose of an exploratory grid is to establish a systematic reference system for locating and recording all data during a survey. By dividing the area into a regular network, geologists can ensure consistent coverage and accurately plot the locations of samples and geological observations. This organization is essential for creating precise maps and for interpreting the results of exploration programs.

182. (A) Timing of mineralization relative to host rock formation.
The fundamental difference between syngenetic and epigenetic mineral deposits is the timing of the mineralization process relative to the formation of the host rock. Syngenetic deposits form at the exact same time as the rock that contains them, while epigenetic deposits are created much later when mineralizing fluids are introduced into pre-existing rocks. This distinction is vital for understanding deposit geometry.

183. (C) Seismic reflection method
The seismic reflection method is the most effective geophysical tool for directly mapping complex subsurface structures like folds and faults within sedimentary layers. By analyzing how sound waves bounce off geological interfaces, geophysicists can produce a detailed image of the crustal architecture. This capability makes seismic reflection indispensable for the oil and gas industry and for understanding regional structural geology at depth.

184. (D) Secondary dispersion
Secondary dispersion refers to the redistribution of chemical elements from a primary ore body into the surrounding environment due to weathering and surface processes. As minerals break down, their constituent elements are transported by water and gravity into the local soils and stream sediments. These dispersion patterns create broad halos that geologists use as targets to find the hidden source of mineralization.

185. (C) Statement I is true, but Statement II is false.
Geochemical exploration involves the systematic measurement of chemical properties in naturally occurring materials to locate mineral deposits. While pathfinder elements help identify potential targets, finding a high concentration in a soil sample does not guarantee the presence of an economic ore body directly beneath it. Dispersion processes can move elements far from their source, requiring further investigation to confirm the discovery.

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186. (C) Breaking the rock by a series of rapid impacts.
Percussion drilling operates on the mechanical principle of shattering rock through a series of rapid and powerful impacts. A heavy bit is repeatedly hammered into the rock surface, breaking it into small chips and fragments. This method is highly effective for drilling in hard and brittle formations, where the impact force can easily overcome the structural strength of the rock mass.

187. (D) The excavation void from which ore has been extracted.
In the context of underground mining, a stope is the specific excavation or void that is created as valuable ore is systematically removed from a deposit. The size and shape of a stope are determined by the geometry of the ore body and the mining method used. Stopes represent the active production areas where the bulk of the mineral extraction occurs.

188. (C) P-4, Q-2, R-1, S-3
Different mining terms are associated with specific operations. Overburden refers to the waste material removed in open-cast mining. A dredge is equipment used for extracting minerals in alluvial mining. Roof bolts are essential for ground support in underground mining. A hoist is the mechanical system used for vertical transport through a shaft, moving personnel and ore to the surface and levels.

189. (C) Longwall mining
Longwall mining is a highly efficient underground method specifically designed for the large-scale extraction of coal from flat-lying seams. This technique utilizes a mechanical shearer to cut coal along a long wall under a movable hydraulic support system. As the machine advances, the coal is transported out of the mine, and the roof behind the supports is allowed to collapse.

190. (B) Gravity separation
Heavy medium separation, jigs, and shaking tables are all important techniques within the broader category of gravity separation. These methods share the fundamental principle of using differences in specific gravity to separate valuable minerals from lighter waste material. They are widely used in the mineral processing industry to concentrate a variety of ores, ranging from coal and iron to heavy minerals.

191. (A) Both A and R are true and R is the correct explanation of A.
Industrial screening is a vital process used to separate ore particles into distinct size fractions. This sizing is necessary because the efficiency of subsequent processing stages, such as grinding or chemical concentration, often depends on having a consistent feed size. By ensuring the material falls within an optimal range, screening helps maximize the overall performance and recovery of the mineral processing plant.

192. (D) Froth Flotation
Froth flotation is a sophisticated mineral dressing technique that exploits differences in the surface chemistry of various minerals. By using specific reagents, some mineral surfaces are made water-repellent, causing them to attach to air bubbles and float. Other minerals remain water-attracting and sink. This method is exceptionally effective for separating finely ground valuable minerals from gangue, particularly in complex sulfide ores.

193. (A) Lead-zinc mining and smelting.
The Zawar Mines in Rajasthan are historically significant as a site of ancient lead and zinc mining and smelting in India. Evidence found at the location reveals that miners were extracting these metals centuries ago using advanced metallurgical processes. The site provides a unique window into the history of Indian technology, particularly the mastery of zinc distillation, which was once a secret.

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194. (A) 1 and 2 only
In a mineral dressing plant, jaw crushers and ball mills are the primary pieces of equipment used for comminution, or size reduction. Jaw crushers perform the initial coarse breaking of large rocks, while ball mills are used for the subsequent fine grinding stage. Screens, however, are used for sizing and separation rather than for breaking the rock into smaller fragments during processing.

195. (B) Porosity measures storage; permeability measures flow.
The fundamental difference between porosity and permeability lies in what they measure within a geological formation. Porosity is the

percentage of void space in a rock, representing its total storage capacity for fluids like water. Permeability, in contrast, measures the ability of those void spaces to be interconnected, allowing fluids to flow through the material. Both properties are essential for aquifers.

196. (A) Precipitation
Precipitation is a central process in the hydrological cycle where water vapor in the atmosphere cools and condenses into liquid droplets or ice crystals. When these become heavy enough, they fall to the Earth's surface as rain, snow, sleet, or hail. This process is the primary mechanism for delivering freshwater to land surfaces, replenishing rivers, lakes, and subsurface groundwater reservoirs.

197. (D) The water table forms the upper boundary.
An unconfined aquifer is a groundwater system where the water-bearing formation is open to the atmosphere and is not trapped beneath an impermeable layer. In this type of system, the upper surface of the saturated zone is defined by the water table. This table can rise or fall freely depending on the amount of recharge from precipitation or the rate of pumping.

198. (B) pH
Assessing groundwater involves measuring various parameters to determine its quality. Physical characteristics include properties such as temperature, turbidity, and color, which describe the water's appearance and thermal state. In contrast, pH is a chemical characteristic that measures the acidity or alkalinity of the water based on the concentration of hydrogen ions. It is not considered a physical trait of the fluid.

199. (C) Conserve soil and water and increase infiltration.
The practice of constructing contour bunds and terraces as part of integrated watershed management is designed to reduce the speed of surface runoff on slopes. By slowing down the water, these structures help to minimize soil erosion and provide more time for water to soak into the ground. This conserves both soil and water while significantly increasing the infiltration into aquifers.

200. (A) Artificial recharge of groundwater.
An injection well is a specialized technology used for the artificial recharge of groundwater. It involves drilling a well directly into an aquifer and pumping water into it to replenish depleted stores. This method is particularly useful in areas where natural infiltration is slow or where there is a surplus of surface water that can be stored underground for future use during droughts.

201. (C) Trenching
Trenching is an exploration technique that provides geologists with the opportunity for direct observation and sampling of near-surface geological materials. By excavating a long, narrow opening in the ground, the bedrock can be exposed and examined for evidence of mineralization. This direct contact with the rock is essential for verifying anomalies found through indirect geophysical or geochemical methods during early exploration.

202. (A) The concentration of the valuable mineral or metal.
The grade of an ore is a critical quantitative measurement determined through chemical assaying. It represents the concentration of a valuable mineral or metal within a given quantity of rock. Grade is typically expressed as a percentage or in grams per tonne. This measurement is the primary factor in determining the economic value of a deposit and the profitability of mining.

203. (D) Feasibility assessment status.
In the United Nations Framework Classification system for mineral resources, the F-axis specifically stands for the status of feasibility assessment. This axis categorizes a project based on the maturity of studies regarding mining methods, processing techniques, and infrastructure requirements. It reflects how much work has been done to determine if the mineral resource can be converted into an economically viable reserve.

204. (D) Both Statement I and Statement II are false.
Placer sampling is not intended for the evaluation of deep, hard-rock vein deposits; instead, it is specifically designed for unconsolidated surficial materials. This method is used to assess deposits of heavy minerals, such as gold or tin, that have been concentrated by natural processes in

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riverbeds and other sedimentary environments. It focuses on recovering and analyzing minerals from sands and gravels.

205. (A) Geophysics measures physical traits; geochemistry chemical ones.
The primary difference between geophysical and geochemical surveys lies in the types of properties they measure to find mineral deposits. Geophysical methods focus on identifying contrasts in physical traits like density, magnetism, and electrical conductivity. Geochemical surveys, however, involve the chemical analysis of samples from soil, rock, or water to detect elevated concentrations of specific elements that indicate nearby mineralization.

206. (A) Mobility in the geochemical cycle.
The tendency of a chemical element to be leached from its host rock and transported away by groundwater is defined by its mobility in the geochemical cycle. Some elements dissolve easily and travel great distances, while others are relatively immobile and remain near the original source. Understanding this mobility is essential for geologists to interpret geochemical anomalies and trace them back to mineralization.

207. (D) A vertical body of magnetite within limestone.
A vertical body of magnetite situated within a host rock like limestone would produce an exceptionally prominent magnetic anomaly. Magnetite has very high magnetic susceptibility, while limestone is virtually non-magnetic. This massive contrast in magnetic properties creates a strong localized signal that can be easily detected and mapped using geophysical instruments, even when the ore body is buried deep underground.

208. (A) Is geochemically associated and more easily found.
In mineral exploration, a pathfinder element is an element that is geochemically associated with a target ore but is easier to find or detect. Because these elements often form broader dispersion halos in the environment, they provide a larger target for geologists to follow. Identifying a pathfinder in soil or stream sediments can lead to the discovery of hidden primary mineralization nearby.

209. (D) Whether ore is extracted from the surface or tunnels.
The classification of mining methods into open-cast and underground categories is primarily based on how the ore is accessed and extracted. Open-cast mining involve removing surface material to reach the deposit from above, creating an open pit. Underground mining, conversely, requires the use of shafts, tunnels, and other subterranean openings to reach and remove ore located at much greater depths.

210. (A) A large dump truck
Large dump trucks are the central component of the haulage system in a modern open-pit mine. These massive vehicles are designed to transport huge volumes of blasted ore and waste rock from the bottom of the pit to the processing plant or waste dumps. Efficient truck haulage is critical for maintaining the high production rates characteristic of large-scale surface mining operations.

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211. (D) To carry out the bulk extraction of the ore body.
The primary purpose of stoping in an underground mining operation is to carry out the bulk extraction of the ore body once development has been completed. This process involves the systematic removal of the mineralized rock between different levels or drifts. Stoping is the main production phase of the mine, where the valuable resources are finally recovered for further processing and sale.

212. (B) Radioactivity
Mineral dressing separation techniques are based on several physical properties of minerals. Specific gravity is the basis for gravity separation, magnetic susceptibility is used in magnetic separation, and surface wettability is exploited in froth flotation. While some minerals are naturally radioactive, this property is generally used for detection and mapping during exploration rather than as a primary mechanism for industrial mineral processing.

213. (C) Grinding mill
A ball mill or rod mill is a type of grinding mill used in the final stages of comminution. These machines utilize grinding media, such as steel balls or rods, to reduce crushed ore into a

285. (A) Forms a larger and more detectable geochemical halo.
In mineral exploration, a pathfinder element is particularly useful because it typically forms a larger and more easily detectable geochemical halo in the environment than the target ore element. These elements are more mobile during weathering, creating a broader target for geologists. By finding pathfinder elements in soil or sediments, geochemists can more efficiently locate hidden mineral deposits at depth.

286. (C) Vertical transport of men and materials in a shaft.
In the technical vocabulary of mining, winding is the term used for the vertical transport of personnel, equipment, and materials through a mine shaft. This system uses hoists and cages to move loads between the surface and the various underground levels. It is an essential component of deep mining operations, ensuring safe and efficient access to and from the workings.

287. (C) Evaporation
Evaporation is a key component of the hydrological cycle, where liquid water on the Earth's surface is converted into water vapor by solar energy. This process allows water to enter the atmosphere, where it can later condense and fall as precipitation. Evaporation is the primary mechanism for the movement of water from the oceans and land into the air.

288. (B) Primary, coarse crushing of run-of-mine ore.
A jaw crusher is a fundamental piece of equipment used in the early stages of mineral dressing for primary, coarse crushing. It is designed to handle large, unrefined pieces of run-of-mine ore as they are first delivered from the mining site. The crusher breaks these boulders into smaller, more manageable fragments that can then be processed in subsequent stages of reduction.

289. (B) Area where all surface water drains to a common point.
A watershed is defined as an area of land where all the surface water and runoff drain into a common point, such as a river, lake, or ocean. The boundaries of a watershed are determined by topography and high points like ridges. Managing water within these natural boundaries is considered the most effective way to address environmental and resource issues.

290. (B) Density
The gravity method of geophysical exploration is based on detecting minute subsurface variations in rock density. Different types of rocks and minerals have different densities, which slightly alter the local gravitational pull at the Earth's surface. By measuring these small differences, geophysicists can map the distribution of materials deep underground, helping to identify potential ore bodies or other structures.

291. (A) Both A and R are true and R is the correct explanation of A.
In an unconfined aquifer, the water level measured in a well typically corresponds directly to the water table. This is because an unconfined aquifer has a free water surface that is directly exposed to atmospheric pressure through the overlying soil and rock pores. This lack of confinement allows the water level in the well to reflect the actual saturated surface.

292. (B) Detailed info on rock type and texture is required.
Core sampling is the preferred exploration drilling method when detailed information about rock type, texture, and geological structure is required. This method provides an intact, cylindrical sample of the subsurface, allowing geologists to directly examine the rock and its mineral content. This high-quality data is essential for accurate geological modeling and for understanding the complex characteristics of a mineral deposit.

293. (A) Identify anomalies indicating potential mineralization.
The primary purpose of a geochemical exploration survey is to identify anomalies that indicate the presence of potential mineralization. By systematically analyzing the chemical composition of soil, rock, and water samples, geologists can detect areas with unusually high concentrations of specific elements. These anomalies serve as targets for more intensive exploration activities like drilling, helping to locate hidden ore bodies.

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assessment includes mining and processing costs, commodity prices, infrastructure requirements, and environmental regulations. Together, these elements determine the portion of a mineral resource that can be profitably extracted under current market conditions.

223. (C) Primary happens at depth; secondary happens at surface.
The fundamental difference between primary and secondary dispersion in geochemistry is the environment and timing of the process. Primary dispersion occurs at depth during the original formation of the ore deposit and host rock. Secondary dispersion, however, takes place at or near the surface when the ore body is exposed to weathering, redistributing the elements into soil and water systems.

224. (A) 1 and 2 only
Gravity and magnetic methods are classified as potential field geophysical techniques because they measure naturally existing fields of the Earth. These methods do not require an artificial energy source to be introduced into the ground. In contrast, the seismic method is an active technique that requires the generation of sound waves through controlled explosions or mechanical impacts to map subsurface geology.

225. (B) An electric hand drill.
A rotary drilling rig is most analogous in its cutting action to an electric hand drill. Both devices operate by rotating a specialized bit under pressure to grind or cut through a material. In drilling, this rotating action allows the bit to penetrate deep into geological formations, whereas other methods like percussion drilling rely on a hammering action similar to a chisel.

226. (B) Underground mining
Stoping methods refers to a classification of excavation techniques specifically used within underground hard rock mining. These methods define how the ore is systematically removed and how the resulting voids are supported during the extraction process. This terminology is not applicable to surface mining, alluvial operations, or initial exploration sampling, as it describes the actual production phase of a mine.

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227. (A) Haulage is horizontal; winding is vertical transport.
The key difference between haulage and winding in a deep underground mine is the direction of transport. Haulage refers to the horizontal movement of ore, waste rock, and materials along the mine levels or tunnels. Winding describes the vertical hoisting of people, equipment, and extracted mineral through a shaft. Both systems are essential for the efficient movement of material throughout.

228. (A) To reduce particle size and liberate minerals from gangue.
The primary goal of the crushing and grinding stages in mineral dressing is to systematically reduce the particle size of the ore. This size reduction is necessary to achieve liberation, where the grains of valuable minerals are physically separated from the surrounding waste rock. Once liberated, the minerals can then be effectively concentrated using various physical or chemical separation techniques later.

229. (C) Wettability (hydrophobicity/hydrophilicity)
The froth flotation process for concentrating sulphide ores relies on the precise control of mineral surface wettability. By using chemical reagents, the surfaces of the valuable minerals are made hydrophobic, or water-repellent. This allows them to attach to air bubbles and float, while the hydrophilic gangue minerals remain attracted to the water and sink, facilitating a clean and efficient separation.

230. (B) Meteoric water originating as precipitation.
The origin of most groundwater is predominantly from meteoric water, which begins as precipitation like rain or snow. As this water falls onto the Earth's surface, a significant portion infiltrates the soil and moves downward through pore spaces and fractures until it reaches the water table. This continuous natural process is the primary source of replenishment for aquifers around the world.

231. (D) Permeability
Permeability is the specific term used in hydrogeology to describe a rock's ability to allow water to pass through it. This property depends on the size and interconnectedness of the void spaces within the material. A rock with high

very fine powder. This process is essential for liberating the individual mineral grains from the gangue, allowing them to be efficiently separated in subsequent processing steps.

214. (D) Gravity separation
To separate cassiterite from quartz, gravity separation would be the most effective method due to the significant difference in their specific gravities. Cassiterite is a very dense mineral, while quartz is relatively light. By using equipment like shaking tables or jigs in a water medium, the denser cassiterite can be easily separated from the less dense quartz particles based on density.

215. (A) It is the largest source of fresh, liquid water available.
Groundwater is of immense importance as a natural resource because it represents the largest source of fresh, liquid water available on Earth. It is a vital supply for billions of people, supporting agriculture, industry, and domestic needs, especially in regions with limited surface water. Effective management and conservation of this resource are essential for ensuring long-term water security and environmental health.

216. (A) An aquiclude
A rock layer composed of unfractured and dense granite would likely be classified as an aquiclude. Because the material is dense and lacks interconnected fractures or pore spaces, it is virtually impermeable and cannot transmit groundwater in any significant quantity. Such formations act as barriers to water flow, often confining aquifers or preventing the downward migration of water within the subsurface system.

217. (A) Manage resources in a holistic way within a drainage basin.
The primary purpose of watershed management is to manage the natural resources of a drainage basin in a holistic and integrated manner. This approach aims to balance the needs of various stakeholders while conserving soil, water, and biodiversity. By treating the entire watershed as a single unit, management practices can more effectively reduce erosion, improve water quality, and ensure sustainable development.

218. (B) P-3, Q-1, R-4, S-2
Hydrogeology is built upon several core concepts. The hydrological cycle describes the continuous movement of water globally. Aquifer classification helps differentiate between confined and unconfined systems. Darcy's Law provides a quantitative method for calculating groundwater flow rates through porous media. Water harvesting focuses on the capturing and storing of rainwater as a sustainable strategy for managing local water supplies and recharge.

219. (B) Diverting stream water into spreading basins.
An example of artificial groundwater recharge is the diversion of stream water into engineered spreading basins. These shallow ponds allow water to gradually soak into the ground, replenishing the underlying aquifer at a rate faster than would occur naturally. This practice is a deliberate human intervention designed to manage and increase the amount of water stored in the subsurface for future use.

220. (B) The near-surface geology and geometry of the ore body.
The evaluation of a mineral deposit through exploratory grids, pitting, and trenching focuses on understanding the near-surface geology and the geometry of the ore body. These methods allow geologists to directly observe and map the extent of mineralization at or just below the surface. This information is critical for determining the size of the deposit and for planning further exploration.

221. (A) Both A and R are true and R is the correct explanation of A.
Core sampling is generally more expensive per meter than other drilling methods because it is a slower and more complex process. It requires specialized equipment to recover an intact rock cylinder from the borehole. However, the higher cost is justified because the resulting core provides invaluable and detailed geological information that cannot be obtained through faster, non-coring methods during exploration.

222. (C) Economic and technical factors to assess profitability.
The final calculation of ore reserves is a comprehensive process that combines detailed geological data on volume and grade with an evaluation of economic and technical factors. This

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eventually to grinding represents a move towards progressively finer particle size reduction. Each subsequent stage is designed to break down the material further until the desired size for mineral liberation is achieved. This systematic approach ensures that the ore is prepared correctly for various concentration and separation techniques.

241. (C) Gravity Separation
Heavy Medium Separation is a sophisticated concentration process that belongs to the broader category of gravity separation. It uses a fluid of controlled density to sort mineral particles based on whether they float or sink. This method is highly effective for separating minerals with distinct physical densities and is commonly used in the processing of coal, iron ore, and various industrial minerals.

242. (B) Distillation of zinc from its ore.
The Zawar Mines in Rajasthan are a significant example of ancient Indian metallurgy primarily because of the clear archaeological evidence for the large-scale distillation of zinc. Zinc is difficult to produce as it vaporizes at the temperatures needed for reduction. The discovery of sophisticated retort furnaces at Zawar proves that ancient Indian metallurgists had mastered this advanced and complex process centuries ago.

243. (B) Hydrological Cycle
The continuous circulation of water from the oceans to the atmosphere through evaporation, onto the land as precipitation, and eventually back to the sea is called the hydrological cycle. This global system is essential for redistributing freshwater across the planet and for sustaining all life. It involves various reservoirs, including surface water, subsurface groundwater, and the atmosphere, all linked by water movement.

244. (B) Aquitard
A body of rock or sediment that has the capacity to store water but cannot transmit it in significant quantities is called an aquitard. These formations have low permeability, meaning that while they contain water in their pore spaces, the water cannot move through them easily. Aquitards play a crucial role in hydrogeology by acting as confining layers for more productive aquifers.

245. (B) Chemical characteristics.
The presence of high concentrations of dissolved minerals like iron and manganese in groundwater is a measure of its chemical characteristics. These substances are leached from the surrounding rocks and soil as water percolates through the subsurface. Monitoring these chemical properties is essential for determining the suitability of the water for various uses and for identifying potential issues like staining or taste.

246. (C) Lowering instruments to measure rock properties.
Well logging is a technique used during the evaluation of mineral and energy deposits that involves lowering specialized instruments into a borehole. These probes measure and record the in-situ physical properties of the surrounding rock formations, such as radioactivity, density, and electrical resistivity. This data provides a continuous and detailed profile of the subsurface geology without requiring physical rock sample extraction.

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247. (A) Avoid missing a potential ore body due to haphazard exploration.
The primary reason for using a systematic exploratory grid is to ensure complete coverage of a survey area and to avoid missing potential mineral deposits. By sampling and mapping at regular, predetermined intervals, geologists can identify localized anomalies that might be overlooked with a more haphazard approach. This systematic method provides a high level of confidence in the final exploration results.

248. (B) P-2, Q-1, R-4, S-3
Mineral processing involves several stages, each using specialized equipment. Primary crushing is typically done with a jaw crusher to break large rocks. Fine grinding is performed in a ball mill to liberate mineral grains. Sizing is achieved using screens to sort particles by size. Finally, gravity separation techniques like using a shaking table concentrate valuable minerals based on their specific gravity.

249. (C) It analyzes travel times of sound waves in the subsurface.
The key principle of the seismic exploration method is the analysis of travel times of sound waves as they move through different subsurface

chemical composition of vegetation as an indicator of underlying mineralization. Certain plant species thrive in metal-rich soils, while others show characteristic growth changes. By studying these botanical signals, geologists can identify potential targets for further investigation in areas where the bedrock is covered by soil and vegetation.

268. (D) Seismic reflection method
Active geophysical methods are those that require an artificial energy source to be introduced into the ground to measure the subsurface response. The seismic reflection method is a prime example, as it relies on generating shock waves via explosions or mechanical impacts. In contrast, passive methods like gravity and magnetic surveys measure naturally occurring fields without the need for an external source.

269. (D) Mining flat-lying deposits like coal or salt.
The room and pillar method is a standard underground mining technique used primarily for extracting flat-lying mineral deposits such as coal, salt, or potash. This method involves removing portions of the material to create rooms while leaving large blocks, or pillars, in place to support the roof of the workings. This approach provides safe and stable access for equipment and personnel.

270. (B) Ancient mining and metallurgy in India.
The historical significance of the Zawar Mines in Rajasthan lies in their role as a premier example of ancient mining and metallurgy in India. Extensive evidence at the site, including deep old workings and advanced zinc distillation retorts, showcases the technical prowess of early Indian metallurgists. This location provides essential insights into the history of industrial-scale mineral processing and metal extraction.

271. (B) Flow velocity to hydraulic gradient and conductivity.
Darcy's Law fundamentally relates the flow velocity of groundwater to the hydraulic gradient and the hydraulic conductivity of the porous medium. This mathematical principle states that the rate at which water moves through an aquifer is driven by the pressure difference and the ability of the material to transmit fluid. It is the essential equation for all groundwater modeling and resource management.

272. (C) Water moves from the surface into the ground.
In the context of the hydrological cycle, infiltration is the process by which water from precipitation or surface water bodies moves from the Earth's surface into the subsurface. This water percolates downward through pore spaces and fractures until it reaches the water table, where it becomes part of the groundwater system. This process is the primary natural method for recharging aquifers.

273. (C) Is legally and economically extractable at a profit.
The term ore reserves implies that a mineral deposit is not just known to exist, but has been proven to be legally and economically extractable at a profit. This classification requires a thorough assessment of technical, economic, and environmental factors. Only when a deposit can be successfully mined under current conditions can it be officially categorized as a reserve rather than a resource.

274. (B) During and around the original ore-forming event.
A primary dispersion pattern in geochemical exploration refers to the distribution of elements that occurred during and immediately surrounding the original ore-forming event. This dispersion happens within the solid bedrock as mineralizing fluids interact with the host rock. Identifying these primary halos allows geologists to locate the core of a mineral deposit, even when it is not directly visible at the surface.

275. (C) Statement I is true, but Statement II is false.
Open-cast mining is a surface extraction technique that involves removing overlying waste rock to expose and extract mineral deposits. Stoping, however, is not a general term for all underground mining; instead, it specifically refers to certain excavation methods used in hard rock mining. Coal mining, for instance, uses different techniques like longwall or room and pillar that are typically not called stoping.

276. (C) Magnetic susceptibility
Magnetic separation is a mineral processing technique that exploits the differences in

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structures, while others are easily leached during weathering. Understanding these factors allows geochemists to select the best sampling media and analytical methods to identify anomalies and find mineralization.

259. (C) Reduced soil erosion and improved water quality.
A major environmental benefit of effective watershed management is the significant reduction in soil erosion and the resulting improvement in water quality. By implementing practices such as afforestation, contouring, and constructing check dams, the speed of surface runoff is reduced. This prevents fertile soil from being washed away and keeps local water bodies clearer by reducing the amount of suspended sediment.

260. (B) III, I, II
The hydrological cycle follows a logical sequence starting from the ocean. The process begins with evaporation as water vapor rises into the atmosphere. This vapor then condenses and falls back to Earth as precipitation. Once on the land, a portion of this water enters the subsurface through infiltration, replenishing groundwater and eventually returning to the sea through underground flow.

261. (C) Haulage
In the technical terminology of underground mining, the system used for the horizontal transport of ore, waste rock, and materials along tunnels and levels is called haulage. This process moves the broken rock from the production faces to a central point, such as a shaft, for removal to the surface. It is distinct from winding, which handles the vertical transportation.

262. (B) It cuts a continuous groove of uniform size across a face.
Channel sampling is a systematic exploration technique where a continuous groove or channel of uniform size is cut across a mineralized face. This method ensures that the collected sample is representative of the entire width of the exposure. It is a far more reliable way to estimate the average grade of an ore body than taking random grab samples from the rock.

263. (B) The portion demonstrated to be economically mineable.
In the UNFC system, the key difference between a mineral resource and a mineral reserve is that a reserve is the specific portion of a resource that has been proven to be economically and technically mineable. This classification requires detailed feasibility studies that consider mining methods, costs, and current market prices. Only after these factors are confirmed can a resource be upgraded.

264. (B) Reduce crushed ore to a fine powder to liberate grains.
The primary function of a grinding mill in a mineral processing circuit is to reduce the size of already crushed ore into an extremely fine powder. This fine size is necessary to achieve liberation, where individual mineral grains are physically freed from the waste rock. Once liberated, the valuable minerals can be efficiently concentrated through processes such as flotation or magnetic separation.

265. (B) Differences in specific gravity (density) of minerals.
The fundamental principle of gravity separation in mineral dressing is to exploit the differences in specific gravity among minerals. In a fluid medium, denser particles settle more rapidly or follow different trajectories than lighter ones. This natural physical property is used in equipment like jigs and shaking tables to effectively separate and concentrate valuable minerals from the lighter surrounding waste rock material.

266. (A) It is overlain by an impermeable layer (aquiclude).
A confined aquifer is more protected from surface-based pollution than an unconfined system because it is overlain by an impermeable layer of rock or sediment, known as an aquiclude. This barrier blocks the downward migration of contaminants from agricultural or industrial activities at the surface. Consequently, the water quality in confined aquifers is generally more stable and less prone to infiltration.

267. (B) Use plant chemistry as an indicator of mineralization.
The main purpose of geobotanical exploration is to use the presence, growth patterns, and

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layers. By generating shock waves and recording their reflections or refractions off geological interfaces, geophysicists can produce detailed images of the Earth's interior. This method is exceptionally powerful for mapping complex underground structures like folds, faults, and stratigraphic boundaries.

250. (A) During the formation of the host rock itself.
Syngenetic diffusion refers to the dispersion of chemical elements that occurs at the same time the host rock itself is forming. This process incorporates the elements into the rock's original structure or texture during crystallization or sedimentation. It is distinct from epigenetic diffusion, where elements are introduced into a rock long after it has already solidified, typically through the migration of fluids.

251. (A) Both A and R are true and R is the correct explanation of A.
An artesian well is one in which groundwater rises above the top of the aquifer without the need for pumping. This phenomenon occurs when a well is drilled into a confined aquifer where the water is under significant pressure. If the pressure is high enough that the potentiometric surface is above the ground level, the water will flow naturally to the surface.

252. (B) Systematic excavation of ore between levels or drifts.
In the context of underground mining, stoping is the process of systematic excavation used to remove ore from a deposit between established levels or development drifts. The size, shape, and support of the resulting stopes depend on the geological conditions and the specific mining method selected. Stoping represents the main production activity where the bulk of the valuable mineral is finally extracted.

253. (D) Crushers are used for initial, coarse size reduction.
In a mineral dressing plant, the role of a crusher is distinct from that of a grinding mill in terms of the scale of size reduction. Crushers are used during the initial stages to perform the coarse breaking of large boulders and pieces of ore. Grinding mills, however, are used later in the process to reduce that material to a very fine powder.

254. (B) 2 and 3 only
To function as an effective aquifer, a geological formation must be both porous and permeable, allowing for the storage and movement of water. Additionally, the hydrological cycle is a massive global system powered by solar energy. However, Darcy's law fundamentally describes the physical flow and movement of groundwater through these media rather than its chemical quality or dissolved mineral content.

255. (A) The depth and geometry of the ore deposit.
The choice between using open-cast or underground mining methods is most critically dependent on the depth and geometry of the ore deposit. Near-surface deposits with a large horizontal extent are typically more economical to mine using open-cast techniques. In contrast, deep or narrow mineralized zones often require the use of underground mining methods to be safely and profitably accessed and extracted.

256. (A) Aquitard
A geological formation like clay, which has high porosity but very low permeability, is best classified as an aquitard. Although clay can hold a significant amount of water within its tiny pore spaces, those spaces are not well-connected, preventing water from flowing through it easily. Aquitards act as barriers within the subsurface, often restricting the vertical movement of groundwater between aquifers.

257. (B) To capture and store precipitation for dry periods and recharge.
The primary aim of water harvesting is to capture and store precipitation, such as rainwater, for future use during dry periods. This sustainable practice helps to supplement water supplies for domestic and agricultural needs. Furthermore, by holding water on the land and allowing it to infiltrate, water harvesting systems also contribute significantly to the artificial recharge of regional groundwater aquifers.

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258. (B) It determines release and detection of anomalies.
In geochemical exploration, the mode of occurrence of trace elements is important because it determines how easily those elements are released and detected in the environment. Some elements are held tightly within mineral

magnetic susceptibility among various minerals. By passing crushed ore through a powerful magnetic field, minerals that are attracted to magnets can be separated from those that are non-magnetic. This physical property is highly effective for concentrating iron ores like magnetite and for removing impurities from a wide range of products.

277. (B) The presence of an overlying impermeable layer.
The classification of groundwater reservoirs as unconfined or confined is fundamentally based on the presence or absence of an overlying impermeable layer, such as an aquiclude. An unconfined aquifer is open to the atmosphere at the water table, while a confined aquifer is trapped beneath a barrier that holds the water under pressure. This structural difference impacts how aquifers are recharged.

278. (C) To manage resources of a basin for sustainable use.
A primary goal of integrated watershed management is to manage all the natural resources within a drainage basin for sustainable use. This holistic approach coordinates the management of soil, water, and vegetation to balance economic needs with environmental conservation. By considering the entire basin as a single system, management practices can more effectively prevent erosion, protect water quality, and ensure long-term sustainability.

279. (C) Determine the concentration of valuable metals.
The purpose of assaying a sample from a mineral deposit is to precisely determine the concentration of valuable metals or minerals within the rock. This quantitative chemical analysis provides the data necessary to calculate the grade of the ore. This information is critical for evaluating the economic potential of a deposit and for planning the processing steps required for commercial production.

280. (A) Percussion hammers rock; rotary breaks by grinding.
The fundamental difference between percussion and rotary drilling lies in the mechanical action used to break the rock. Percussion drilling uses a powerful hammering and chipping action to shatter the material into small fragments. Rotary drilling, in contrast, uses a rotating bit that grinds or cuts through the rock mass. Both methods are essential in exploration, depending on the rock's hardness.

281. (B) Sulphide ores
The froth flotation technique is most widely used for the separation and concentration of sulphide ores. This method exploits differences in the surface properties of minerals, particularly their wettability. By using chemical reagents, the surfaces of sulphide minerals are made water-repellent, allowing them to attach to air bubbles and float. This process effectively separates valuable minerals from the hydrophilic waste rock.

282. (C) Porosity and permeability.
The term hydrological properties of rocks primarily refers to their porosity and permeability. Porosity is a measure of the total void space within a rock that can store water. Permeability describes how well those spaces are interconnected, allowing water to flow through the material. Together, these two properties determine whether a geological formation can function effectively as a productive groundwater aquifer.

283. (C) Pumping treated wastewater into a well to replenish.
An example of artificial recharge is the process of pumping treated wastewater directly into a well to replenish an underlying aquifer. This deliberate human intervention aims to increase the amount of water stored in the subsurface for later use. This method is used in many regions to manage water resources, especially where natural infiltration is insufficient to meet high water demands.

284. (C) Open-cast mining
A large, low-grade mineral deposit exposed at the surface would most economically be mined using open-cast methods. This approach involves removing the surface waste rock to create a massive open pit, allowing for high-volume extraction at a relatively low unit cost. The scale of operation possible with open-cast mining is necessary to make the processing of low-grade ore bodies profitable.

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permeability allows groundwater to move freely, making it a potentially productive aquifer, while a rock with low permeability acts as an aquitard.

232. (D) Statement I is false, but Statement II is true.
Groundwater flow is driven by differences in hydraulic head rather than just simple elevation. While water often moves from higher to lower altitudes, it fundamentally flows from points of higher hydraulic pressure to those of lower pressure. This can sometimes result in water moving upward against gravity in certain geological settings, such as in confined aquifers or near large discharge zones.

233. (A) It is most effective to manage resources within a basin.
The concept of watershed management is built on the principle that it is most effective to manage natural resources within the natural boundaries of a drainage basin. This approach recognizes that water, soil, and vegetation are all interconnected throughout the basin. By planning on a watershed scale, managers can more effectively address issues like erosion, water quality, and sustainable resource use.

234. (B) Transpiration by trees.
Artificial recharge involves engineered systems designed to increase groundwater storage, such as spreading basins, check dams, and injection wells. These methods are deliberate human interventions. In contrast, transpiration by trees is a natural biological process where plants release water vapor into the atmosphere. This process removes water from the soil and is a component of the natural cycle rather than recharge.

235. (B) Guide operations, control grade, and reconcile estimates.
Sampling in an underground mine is conducted to guide daily operations and ensure effective grade control. By analyzing samples from active faces, miners can track the quality of the ore being extracted. This data is also essential for reconciling the actual production results with the original resource estimates, helping to refine geological models and improve future planning and economic forecasts.

236. (C) Economic Viability, Feasibility Assessment, and Geology.
The United Nations Framework Classification provides a standardized system to categorize mineral deposits based on three fundamental criteria: economic and social viability, feasibility assessment status, and the level of geological knowledge. These criteria, represented by three axes, allow for a consistent and transparent way to report resources and reserves on a global scale, facilitating better comparison and investment decision-making.

237. (D) Abnormal element concentrations derived from ore.
A geobotanical anomaly is caused by abnormal concentrations of chemical elements in the soil, which are often derived from an underlying mineral deposit. These elements can affect the health and growth of plants, leading to visible changes like stunted growth, leaf discoloration, or the presence of specific indicator species. Geologists use these biological signals as indirect clues to locate hidden mineralization.

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238. (A) Near-surface environment with oxygenated rainwater.
High mobility of elements that are soluble under oxidizing conditions is promoted in the near-surface environment, where oxygenated rainwater is abundant. As water percolates through the soil and rock, it can easily leach these elements and transport them away. This process is a key part of the formation of secondary dispersion halos, which geochemists target during exploration for mineral deposits.

239. (A) Coal is in sedimentary strata, favoring longwall mining.
The primary difference between coal mining and many other underground mining methods is that coal typically occurs in extensive, relatively flat sedimentary strata. This geological setting favors specialized extraction techniques like longwall or room and pillar mining. Metal deposits, conversely, are often found in more complex and irregular shapes within hard rock, requiring diverse stoping methods for efficient extraction.

240. (B) Progressively finer particle size reduction.
In a mineral dressing plant, the transition from primary crushing to secondary crushing and

294. (D) 1, 2, and 3
Coal mining utilizes several specialized methods depending on the depth and nature of the coal seams. Longwall mining and room and pillar mining are the two most common underground techniques for extracting coal. Additionally, near-surface coal deposits are frequently mined using open-cast methods. All three of these techniques are standard industrial practices for recovering this vital energy resource efficiently.

295. (C) Density
Heavy medium separation is a mineral processing technique that separates particles based on their physical density. It uses a liquid with a controlled density that is between the densities of the minerals to be separated. In this medium, lighter particles float while heavier ones sink. This method is highly effective for sorting minerals with distinct densities in large-scale industrial operations.

296. (C) Hydrogeology
Hydrogeology is the scientific field that studies the distribution and movement of water between surface and subsurface reservoirs. It involves understanding how water interacts with geological materials and how it is stored in aquifers. This discipline is essential for managing water resources, assessing groundwater quality, and planning sustainable water use for domestic, agricultural, and industrial needs around the world.

297. (B) Involves engineered systems to augment storage.
The key difference between natural and artificial recharge of groundwater is that artificial recharge involves deliberate human intervention and engineered systems. While natural recharge occurs through the simple infiltration of precipitation, artificial methods use structures like spreading basins or injection wells to augment this process. These engineered systems are designed to purposefully increase the volume of water entering regional aquifers.

298. (B) Separate particles into different size fractions.
The primary purpose of industrial screening in a mineral processing plant is to systematically separate crushed ore particles into different size fractions. This mechanical sizing is critical because subsequent stages, such as grinding and chemical concentration, are most efficient when they receive a feed material that is uniform and within a specific size range. This ensures optimal recovery of the valuable minerals.

299. (C) Open-cast mining
Open-cast mining is the method in which the overburden, or waste material located above an ore body, is systematically removed to expose the mineral deposit for excavation. This technique creates a large open pit from which the ore can be directly removed. It is the most common approach for mining large mineralized zones that are situated close to the surface.

300. (C) Darcy's Law
Darcy's Law is the fundamental principle that provides the mathematical equation for calculating the rate of groundwater flow through a porous medium. It establishes that the flow rate is directly proportional to both the hydraulic gradient and the hydraulic conductivity of the material. This law is the cornerstone of hydrogeology and is used for all predictive modeling of water movement.

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CHAPTER 10

Geology, Mineral resources, Hydrogeology and Geoheritage of Madhya Pradesh

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1. Which of the following is considered a major stratigraphic unit in Madhya Pradesh, known for its extensive sedimentary rock sequences?
(A) Siwalik Group
(B) Vindhyan Supergroup
(C) Karewa Group
(D) Bhuj Formation

2. Consider the following statements:
Statement I : The Narmada River flows westwards through a well-defined rift valley.
Statement II : This valley is a significant tectonic feature in the geology of Madhya Pradesh.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct, but Statement II is incorrect.
(D) Statement I is incorrect, but Statement II is correct.

3. The Malanjkhand mine in Madhya Pradesh is primarily known for the extraction of which mineral?
(A) Iron Ore
(B) Manganese
(C) Copper
(C) Bauxite

4. Which of the following is NOT considered a major groundwater province in Madhya Pradesh?
(A) Crystalline provinces
(B) Gondwana provinces
(C) Vindhyan provinces
(D) Coastal alluvial provinces

5. Bhimbetka Rock Shelters, a significant geoarchaeological site in Madhya Pradesh, are located in which district?
(A) Hoshangabad
(B) Sehore
(C) Raisen
(D) Bhopal

6. Given below are two statements, one is labelled as Assertion (A) and the other as Reason (R):
Assertion (A) : Madhya Pradesh is a leading state in India for diamond production.
Reason (R) : The Majhgawan mine in the Panna district is the primary source of diamonds in the state.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

7. The term 'Geopark' in the context of Madhya Pradesh's geodiversity primarily refers to:
(A) A recreational facility featuring various geological-themed rides.
(B) A high-level research laboratory used by professional geologists.
(C) A commercial mining area used for regulated mineral extraction.
(D) A protected area showcasing geological heritage for conservation.

8. Which of the following statements about the tectonic features of the Tapti River in Madhya Pradesh is most accurate?
(A) It flows parallel to the Narmada through a similar rift structure.
(B) It flows through a synclinal valley.
(C) It is a consequent river with no tectonic control.

(D) It originates from the Amarkantak plateau, same as Narmada.

9. The Bagh Caves in the Dhar district are most famous for which geoarchaeological feature?
(A) Well-preserved dinosaur fossils
(B) A large collection of Paleolithic stone tools
(C) Intricate rock-cut architecture and ancient murals
(D) Naturally formed limestone stalactites and stalagmites

10. Consider the following statements regarding the mineral wealth of Madhya Pradesh:
1. The state has significant deposits of coal, primarily in the Gondwana formations.
2. The Panna district is historically renowned for its diamond mines.
3. Bauxite reserves are mainly concentrated in the western districts of the state.

Which of the above statement(s) is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

11. Which of the following is a recently designated Ramsar Site (Wetland) located in Madhya Pradesh?
(A) Keoladeo National Park
(B) Loktak Lake
(C) Chilika Lake
(D) Sirpur Lake

12. Identify the incorrect statement regarding the geology of Madhya Pradesh.
(A) The Deccan Traps cover a significant portion of the western part of the state.
(B) The entire state is composed of geologically recent alluvial deposits.
(C) Archaean rocks form the basement complex in many areas.
(D) The Vindhyan Supergroup is a prominent feature of central and northern Madhya Pradesh.

13. A cement plant in the Satna or Rewa region of Madhya Pradesh would most likely source its primary raw material, limestone, from which stratigraphic unit?
(A) Deccan Traps
(B) Gondwana Supergroup
(C) Vindhyan Supergroup
(D) Lameta Formation

14. What defines a 'Rock Monument' in the context of Geodiversity of Madhya Pradesh?
(A) A specific rock type used in creating historical monuments.
(B) A human-made sculpture carved from a single large boulder.
(C) A commemorative monument dedicated to a pioneering geologist.
(D) A natural rock formation with scientific or aesthetic value.

15. The Narmada Valley in Madhya Pradesh is particularly famous for the discovery of fossils from which geological era?
(A) Cenozoic
(B) Precambrian
(C) Paleozoic
(D) Mesozoic

16. Match the following items in List I with those in List II:
List I: (Mineral) P. Coal, Q. Manganese, R. Diamond, S. Bauxite
List II: (Major Mining Area in M.P.) 1. Panna, 2. Bharveli (Balaghat), 3. Amarkantak Plateau, 4. Singrauli
Choose the correct answer from the options given below:
(A) P-4, Q-2, R-1, S-3
(B) P-2, Q-4, R-3, S-1
(C) P-4, Q-1, R-2, S-3
(D) P-3, Q-2, R-1, S-4

17. Which of the following is an example of a man-made ancient waterbody in Madhya Pradesh, reflecting its hydrogeological heritage?
(A) The source of the Narmada river at Amarkantak
(B) Bhojtal (Upper Lake) in Bhopal
(C) The Dhuandhar Falls at Bhedaghat
(D) The Patalpani waterfall

18. The rock art found in the Bhimbetka Rock Shelters predominantly belongs to which prehistoric periods?
(A) Paleolithic, Mesolithic, and later periods
(B) Neolithic and Chalcolithic only

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(C) Iron Age only
(D) Jurassic and Cretaceous periods

19. Given below are two statements, one is labelled as Assertion (A) and the other as Reason (R):
Assertion (A) : The Gondwana formations in Madhya Pradesh are economically very significant.
Reason (R) : They contain over 90% of India's coal reserves.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

20. Arrange the following major stratigraphic units of Madhya Pradesh in chronological order from oldest to youngest.
1. Deccan Traps
2. Vindhyan Supergroup
3. Archaean Basement Complex
4. Gondwana Supergroup

Select the correct answer using the code given below:
(A) 3, 2, 4, 1
(B) 2, 3, 1, 4
(C) 3, 4, 2, 1
(D) 1, 4, 2, 3

21. The WCL (Western Coalfields Limited) and NCL (Northern Coalfields Limited) operate major coal mines in Madhya Pradesh. These mines primarily exploit coal from which geological sequence?
(A) Vindhyan Supergroup
(B) Archaean Gneissic Complex
(C) Gondwana Supergroup
(D) Deccan Traps

22. Consider the following statements:
Statement I : Geotourism in Madhya Pradesh aims to promote tourism to geological sites without considering their conservation.
Statement II : The development of Geoparks is a key prospect for enhancing geotourism in the state.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is incorrect, but Statement II is correct.
(D) Statement I is correct, but Statement II is incorrect.

23. Consider the following statements about the Ghughwa Fossil Park in Madhya Pradesh:
1. It is located in the Dindori district.
2. The fossils primarily consist of plant and tree specimens.
3. The fossils date back to the Cretaceous period.

Which of the above statement(s) is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

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24. The term 'graben' is often used to describe the Narmada-Tapti tectonic structure. What does it signify?
(A) A down-dropped block of land between two normal faults.
(B) An uplifted block of land between two normal faults.
(C) A fold in the rock strata forming an arch.
(D) A large-scale volcanic caldera.

25. Which of the following is NOT a recognized Ramsar site in Madhya Pradesh?
(A) Bhoj Wetland
(B) Sakhya Sagar
(C) Tawa Reservoir
(D) Yashwant Sagar

26. The marble rocks at Bhedaghat, a famous geotourism site, are part of which geological formation?
(A) Deccan Traps Basalt
(B) Vindhyan Sandstone
(C) Precambrian Marbles
(D) Gondwana Shale

27. A geologist finds a sequence of sandstone, shale, and limestone with stromatolite fossils in central Madhya Pradesh. To which major stratigraphic unit would they most likely assign these rocks?
(A) Gondwana Supergroup
(B) Deccan Traps
(C) Vindhyan Supergroup

(D) Lameta Formation

28. The presence of numerous ancient man-made waterbodies (talabs) in regions like Bundelkhand is an indicator of:
(A) Ancient traditions of harvesting rainwater in water-scarous areas.
(B) Historical indicators of a region with surplus natural water.
(C) Evidence showing the total non-existence of natural waterways.
(D) A modern government project lacking any historical precedent.

29. Match the following items in List I with those in List II:
List I: (Geoheritage Site) P. Bhimbetka, Q. Bhedaghat, R. Bagh Caves, S. Ghughwa
List II: (Associated Feature) 1. Marble Rocks Gorge, 2. Plant Fossils, 3. Rock-cut Buddhist Viharas, 4. Prehistoric Rock Art
Choose the correct answer from the options given below:
(A) P-1, Q-2, R-3, S-4
(B) P-4, Q-1, R-3, S-2
(C) P-4, Q-3, R-1, S-2
(D) P-2, Q-1, R-4, S-3

30. The groundwater provinces of Madhya Pradesh are primarily determined by the:
(A) Annual rainfall patterns.
(B) Underlying lithology and geological structure.
(C) Density of human population.
(D) Predominant crop types in the region.

31. Which of the following best describes the tectonic setting of the Narmada-Son Lineament?
(A) A zone of compressional tectonics creating massive fold mountains.
(B) A subduction zone where one tectonic plate slides under another.
(C) An intra-plate region characterized by no significant activity.
(D) A major west-east trending zone of structural faulting and weakness.

32. Given below are two statements, one is labelled as Assertion (A) and the other as Reason (R):
Assertion (A) : The Deccan Traps are classified as flood basalts.
Reason (R) : They were formed by highly fluid lava flows erupting from fissures, covering vast areas of western and central India, including parts of Madhya Pradesh.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

33. Which mineral-based industry is heavily concentrated in the Katni district, often referred to as the 'Limestone City'?
(A) Copper smelting
(B) Aluminium refining
(C) Cement and lime production
(D) Diamond cutting and polishing

34. Sakhya Sagar, a Ramsar site in Madhya Pradesh, is an integral part of which National Park?
(A) Kanha National Park
(B) Bandhavgarh National Park
(C) Panna National Park
(D) Madhav National Park

35. The discovery of dinosaur fossils and eggs in the Narmada Valley, particularly in the Dhar and Jabalpur regions, is associated with which geological formation?
(A) Lameta Formation
(B) Vindhyan Supergroup
(C) Gondwana Supergroup
(D) Deccan Traps

36. Consider the following statements about the Vindhyan Supergroup in Madhya Pradesh:
1. It is largely unfossiliferous, except for microfossils and stromatolites.
2. It is a major source of building stones like sandstone and limestone.
3. It is younger than the Gondwana Supergroup.
Which of the above statement(s) is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

37. Identify the incorrect pair of a mineral and its associated district in Madhya Pradesh.

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(C) The presence of limestone has led to a thriving cement industry.
(D) Diamond cutting and polishing is a larger industry than diamond mining.

57. The rock-cut caves and monasteries at Bagh are attributed to which period/religious tradition?
(A) Jainism, post-Gupta period
(B) Buddhism, Vakataka-Gupta period
(C) Hinduism, Pratihara period
(D) Ajivika tradition, Mauryan period

58. Given below are two statements, one is labelled as Assertion (A) and the other as Reason (R):
Assertion (A) : The groundwater level in the Malwa plateau, covered by Deccan Traps, is depleting at an alarming rate.
Reason (R) : The basaltic rock, when not weathered or fractured, has very low primary porosity and permeability, leading to high runoff and limited infiltration.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

59. The Narmada Valley is considered a significant geoarchaeological site due to:
(A) The presence of both hominid fossils and a continuous record of stone tool industries.
(B) The abundance of gold and other precious metals.
(C) The location of the capital of the Mauryan Empire.
(D) The discovery of the world's oldest manuscripts.

60. Arrange the declaration of the following as Ramsar sites in Madhya Pradesh in chronological order.
1. Bhoj Wetland
2. Yashwant Sagar
3. Sirpur Lake
4. Sakhya Sagar

Select the correct answer using the code given below:
(A) 1, 2, 3, 4
(B) 1, 4, 3, 2
(C) 4, 3, 2, 1
(D) 1, 3, 4, 2

61. Which of the following best describes the lithology of the Gondwana Supergroup in Madhya Pradesh?
(A) Alternating layers of sandstone, shale, and coal seams.
(B) Massive deposits of limestone and dolomite.
(C) Extensive flows of basaltic lava.
(D) High-grade metamorphic rocks like gneiss and schist.

62. Consider the following statements about the prospects of Geoparks in Madhya Pradesh:
1. The Jabalpur-Bhedaghat area is a prime candidate due to its marble rocks and fossil record.
2. Geoparks focus solely on scientific research, excluding tourism and local community involvement.
3. The main aim is to conserve geodiversity and promote sustainable economic development through geotourism.

Which of the above statement(s) is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

63. The primary water-bearing formations (aquifers) in the 'Gondwana groundwater province' of Madhya Pradesh are:
(A) Fractured basalts
(B) Cavernous limestones
(C) Porous sandstones
(D) Metamorphic quartzites

64. Which of the following is an important mine for coal in the Singrauli district of Madhya Pradesh?
(A) Malanjkhand
(B) Bharveli
(C) Jayant
(D) Majhgawan

65. The art in the Bagh Caves shows a strong influence of the style found at which other famous Indian cave site?
(A) Elephanta Caves
(B) Ellora Caves
(C) Ajanta Caves
(D) Udayagiri Caves

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Statement I : All natural waterbodies in Madhya Pradesh are perennial.
Statement II : Many rivers and lakes in the state are rain-fed and may dry up or reduce significantly during the summer.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is incorrect, but Statement II is correct.
(D) Statement I is correct, but Statement II is incorrect.

48. The establishment of a 'Geopark' in the Jabalpur region, encompassing Bhedaghat and Lameta Ghat, is primarily justified by its:
(A) High concentration of state-wide mineral wealth.
(B) Combination of marble rock gorges and dinosaur fossil sites.
(C) Suitability for large-scale industrial economic development.
(D) Dense forest cover and local wildlife population diversity.

49. Consider the following statements about the tectonic setting of Madhya Pradesh:
1. The Narmada-Son lineament is a major Proterozoic shear zone.
2. The Tapti river flows in a graben structure parallel to the Narmada.
3. The region is tectonically inactive with no recorded seismicity.
Which of the above statement(s) is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

50. The rock art at Bhimbetka provides archaeological evidence of:
(A) The transition from hunting-gathering to agriculture and settled life.
(B) The construction techniques of the Mauryan Empire.
(C) The trade routes with ancient Rome.
(D) The development of early writing systems.

51. Which stratigraphic unit in Madhya Pradesh is characterized by basaltic lava flows?
(A) Vindhyan Supergroup
(B) Gondwana Supergroup
(C) Deccan Traps
(D) Archaean Gneiss

52. The Bharveli mine in the Balaghat district of Madhya Pradesh is Asia's largest producer of:
(A) Copper
(B) Manganese
(C) Iron Ore
(D) Coal

53. 'Yashwant Sagar', recently added to the Ramsar list, is a wetland located near which major city in Madhya Pradesh?
(A) Bhopal
(B) Indore
(C) Jabalpur
(D) Gwalior

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54. The term 'Geoheritage' encompasses all of the following EXCEPT:
(A) Sites with significant fossil records.
(B) Landforms with unique aesthetic or scientific value.
(C) Rock formations that demonstrate key geological processes.
(D) Modern agricultural practices in a region.

55. Match the following items in List I with those in List II:
List I: (Tectonic/Geological Feature) P. Narmada Rift, Q. Deccan Traps, R. Bundelkhand Craton, S. Vindhyan Basin
List II: (Description) 1. Ancient Archaean granitic nucleus, 2. Proterozoic sedimentary basin, 3. Cretaceous-Paleogene flood basalt province, 4. E-W trending graben structure
Choose the correct answer from the options given below:
(A) P-4, Q-3, R-2, S-1
(B) P-4, Q-3, R-1, S-2
(C) P-1, Q-2, R-3, S-4
(D) P-2, Q-1, R-4, S-3

56. Identify the correct statement about mineral-based industries in Madhya Pradesh.
(A) All mineral resources extracted are processed within the state.
(B) The state has no significant thermal power plants despite large coal reserves.

(A) Diamond - Panna
(B) Copper - Balaghat
(C) Coal - Singrauli
(D) Manganese - Sidhi

38. The primary objective of declaring a wetland a 'Ramsar Site' is to:
(A) Conserve the wetland and promote its wise use.
(B) Promote large-scale fishing industries.
(C) Encourage urban development around the waterbody.
(D) Drain the wetland for agricultural purposes.

39. The ancient waterbody 'Bhojtal' in Bhopal was created by constructing a dam across which river?
(A) Narmada
(B) Betwa
(C) Kolans
(D) Tapti

40. Arrange the following geoarchaeological/ geoheritage sites of Madhya Pradesh from north to south.
1. Bagh Caves, Dhar
2. Gwalior Fort (built on Gopachal Parvat)
3. Bhimbetka Rock Shelters, Raisen
4. Bhedaghat, Jabalpur

Select the correct answer using the code given below:
(A) 2, 3, 4, 1
(B) 1, 4, 3, 2
(C) 2, 3, 1, 4
(D) 4, 1, 2, 3

41. What is the primary characteristic of the 'Crystalline groundwater province' in Madhya Pradesh?
(A) Groundwater is stored in the primary porosity of sandstone layers.
(B) Groundwater availability is found in weathered zones and hard rock fractures.
(C) High yield aquifers are common in extensive cavernous limestone zones.
(D) Water is found in unconsolidated alluvial deposits along major rivers.

42. Match the following items in List I with those in List II:
List I: (Industry) P. Thermal Power Plant, Q. Cement Plant, R. Alumina Refinery, S. Copper Smelter
List II: (Likely Location in M.P. based on resources) 1. Satna, 2. Malanjkhand, 3. Singrauli, 4. Korba region
Choose the correct answer from the options given below:
(A) P-1, Q-3, R-2, S-4
(B) P-3, Q-1, R-4, S-2
(C) P-3, Q-4, R-1, S-2
(D) P-2, Q-1, R-4, S-3

43. The fossils found in the Narmada Valley, such as the skull of Homo erectus (Narmada Man), are significant for understanding:
(A) Dinosaur extinction events.
(B) The evolution of marine life.
(C) Early human evolution and migration in the Indian subcontinent.
(D) The origin of flowering plants.

44. Which of the following is NOT a prospect or component of geotourism in Madhya Pradesh?
(A) Visiting fossil parks like Ghughwa.
(B) Boating in the marble rocks gorge at Bhedaghat.
(C) Exploring the rock art at Bhimbetka.
(D) Deep-sea diving to explore coral reefs.

45. Given below are two statements, one is labelled as Assertion (A) and the other as Reason (R):
Assertion (A) : The Bundelkhand Gneissic Complex represents one of the oldest rock formations in Madhya Pradesh.
Reason (R) : These rocks are part of the Archaean Eon basement craton.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

46. The mineral 'dolomite', which has industrial applications, is chemically a:
(A) Sulphate of calcium and magnesium.
(B) Silicate of iron and magnesium.
(C) Carbonate of calcium and magnesium.
(D) Oxide of aluminium.

47. Consider the following statements:

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66. Consider the following statements:
Statement I : The 'Bhoj Wetland' in Bhopal consists of the Upper Lake and the Lower Lake.
Statement II : It was designated as the state's first Ramsar site.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct, but Statement II is incorrect.
(D) Statement I is incorrect, but Statement II is correct.

67. The phenomenon of river capture and presence of deep gorges in the Chambal region of Madhya Pradesh is a manifestation of which geological process?
(A) Glacial erosion
(B) Wind deposition
(C) Fluvial erosion and headward erosion in a tectonically uplifted area
(D) Volcanic activity

68. Match the following items in List I with those in List II:
List I: (District) P. Balaghat, Q. Panna, R. Katni, S. Singrauli
List II: (Prominent Mineral/Geo-resource) 1. Diamond, 2. Coal, 3. Limestone, 4. Manganese
Choose the correct answer from the options given below:
(A) P-4, Q-1, R-3, S-2
(B) P-1, Q-4, R-2, S-3
(C) P-4, Q-3, R-1, S-2
(D) P-2, Q-1, R-3, S-4

69. What is the most significant aspect of the geodiversity of the Mandla Plant Fossils National Park (Ghughwa)?
(A) It contains fossilized remains of large dinosaurs.
(B) It preserves petrified tree trunks and plant fossils from 65 million years ago.
(C) It showcases a complete sequence of marine invertebrate fossils.
(D) It is an active volcanic site with geysers.

70. Which of the following is an example of a natural waterbody in Madhya Pradesh?
(A) Gandhi Sagar Dam
(B) Tawa Reservoir
(C) The plunge pool below Dhuandhar falls
(D) Bhojtal

71. Given below are two statements, one is labelled as Assertion (A) and the other as Reason (R):
Assertion (A) : The Vindhyan sandstones are widely used as a building and ornamental stone.
Reason (R) : The rocks are horizontally bedded, easily quarried, and possess desirable colours and textures.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

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72. A key objective of studying the various stratigraphic units of Madhya Pradesh is to:
(A) Understand the state's political history.
(B) Reconstruct the geological history, climate, and life of past eras.
(C) Determine the current weather patterns.
(D) Only to locate mineral deposits for immediate extraction.

73. The Narmada and Tapti rivers are west-flowing, unlike most major peninsular rivers. This is primarily because they:
(A) Originate in the Western Ghats.
(B) Follow the gradient of pre-existing tectonic troughs (rift valleys).
(C) Receive more rainfall in their western catchment.
(D) Are artificially diverted for irrigation.

74. Which of these is a major mineral-based industry directly dependent on the bauxite reserves of Madhya Pradesh?
(A) Steel manufacturing
(B) Cement production
(C) Aluminium production
(D) Fertilizer production

75. Consider the following statements about Geoarchaeological sites of Madhya Pradesh:
1. Bhimbetka provides evidence for the longest continuous human settlement in India.
2. The Bagh Caves are natural limestone

caverns, not man-made.
3. The Narmada Valley has yielded fossils of both prehistoric animals and early hominids.

Which of the above statement(s) is/are correct?
(A) 1 and 2 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

76. The 'Alluvial groundwater provinces' in Madhya Pradesh are typically found:
(A) In the hilly terrains of the Satpura range.
(B) Along the major river valleys like the Narmada and Chambal.
(C) Covering the entire Malwa plateau.
(D) In the Bundelkhand granitic region.

77. The 'Bhoj Wetland', a Ramsar site, is crucial for the city of Bhopal as it serves as a:
(A) Primary source of drinking water.
(B) Site for industrial waste disposal.
(C) Major shipping and transport hub.
(D) Source of thermal energy.

78. The concept of 'Geotourism' in Madhya Pradesh promotes:
(A) Environmentally responsible travel to natural areas to enjoy and appreciate geological features.
(B) Mass tourism with a focus on entertainment.
(C) Adventure sports that may damage fragile rock formations.
(D) Construction of large hotels directly on geoheritage sites.

79. The age of the rocks in the Vindhyan Supergroup is generally considered to be:
(A) Proterozoic
(B) Archaean
(C) Mesozoic
(D) Cenozoic

80. Arrange the following events related to the geodiversity and geoheritage of Madhya Pradesh in a logical sequence.
1. Formation of Marble Rocks of Bhedaghat.
2. Deposition of sediments containing dinosaur remains (Lameta Formation).
3. Eruption of Deccan flood basalts.
4. Creation of prehistoric paintings at Bhimbetka by early humans.

Select the correct answer using the code given below:
(A) 1, 2, 3, 4
(B) 2, 1, 3, 4
(C) 1, 3, 2, 4
(D) 4, 3, 2, 1

81. Match the following items in List I with those in List II:
List I: (Fossil Park / Site) P. Ghughwa Fossil Park, Q. Bhimbetka Rock Shelters, R. Bagh Caves, S. Narmada Valley Fossil Area (Hathnora)
List II: (District) 1. Raisen, 2. Sehore/ Hoshangabad, 3. Dhar, 4. Dindori
Choose the correct answer from the options given below:
(A) P-1, Q-4, R-3, S-2
(B) P-4, Q-1, R-3, S-2
(C) P-4, Q-2, R-1, S-3
(D) P-2, Q-1, R-4, S-3

82. The iron ore deposits in Madhya Pradesh, though not as extensive as in other states, are mainly found in which region?
(A) Chambal valley
(B) Malwa plateau
(C) Jabalpur and surrounding regions
(D) Baghelkhand plateau

83. Which of the following is the most appropriate description of a 'Geoheritage Site'?
(A) Any specific site characterized by rock outcrops.
(B) A location with geological elements of scientific or cultural value.
(C) An industrial mine that has been exhausted of its minerals.
(D) A man-made park that displays various unique rock types.

84. Given below are two statements, one is labelled as Assertion (A) and the other as Reason (R):
Assertion (A) : The Lameta Formation in Madhya Pradesh is of great paleontological importance.
Reason (R) : It is an infratrappean sedimentary sequence that has yielded a wealth of dinosaur fossils, including nests and eggs.
(A) Both A and R are true and R is the correct explanation of A.

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(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

85. Groundwater in the 'Vindhyan provinces' of Madhya Pradesh is primarily found in:
(A) Large interconnected cave systems.
(B) The pore spaces of unconsolidated sand.
(C) Joints, fractures, and bedding planes of sandstones and limestones.
(D) The vesicles and amygdales of basaltic rocks.

86. Which of the following is NOT a direct industrial use of minerals found prominently in Madhya Pradesh?
(A) Limestone for cement
(B) Coal for thermal power
(C) Bauxite for aluminium
(D) Gold for electronics

87. Consider the following statements:
Statement I : The paintings at Bhimbetka are a monolithic record of a single culture from a single time period.
Statement II : The art at Bhimbetka shows superposition and stylistic changes, indicating continuous occupation and cultural evolution over thousands of years.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is incorrect, but Statement II is correct.
(D) Statement I is correct, but Statement II is incorrect.

88. Consider the following statements regarding the Ramsar sites of Madhya Pradesh:
1. They are all natural, pristine wetlands untouched by human activity.
2. Designation as a Ramsar site legally binds the government to halt all economic activity in the area.
3. The sites are recognized for their international importance, especially as waterfowl habitats.

Which of the above statement(s) is/are correct?
(A) 3 only
(B) 1 and 3 only
(C) 2 and 3 only
(D) 1, 2 and 3

89. A proposal for a Geopark in the Panna region would leverage which unique geological attribute?
(A) Dinosaur fossils
(B) Flood basalt landscapes
(C) Diamond-bearing kimberlite pipe and associated geology
(D) Marble rock canyons

90. The term 'infratrappean' when referring to the Lameta beds signifies that these beds are:
(A) Found within the basalt flows.
(B) Found above the Deccan Traps.
(C) Found below the Deccan Traps.
(D) Unrelated in age to the Deccan Traps.

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91. The correct pair representing a major coalfield and its location in Madhya Pradesh is:
(A) Jharia Coalfield - Shahdol
(B) Raniganj Coalfield - Betul
(C) Singrauli Coalfield - Singrauli
(D) Talcher Coalfield - Chhindwara

92. The hydrogeology of areas covered by Deccan Traps is complex because:
(A) The rock is uniformly porous and permeable.
(B) Groundwater movement is controlled by a dual system of weathered/vesicular zones and deeper fractures.
(C) The rock is completely impermeable, preventing any groundwater storage.
(D) The area is always waterlogged due to high rainfall.

93. The rock paintings at Bhimbetka are considered 'geoarchaeological' sites because:
(A) They represent human-environment interactions within specific rock shelters.
(B) The paintings provide maps of local geological formations.
(C) The pigments used were derived exclusively from regional minerals.
(D) The site remains studied primarily by professional earth geologists.

94. Match the following items in List I with those in List II:

(C) Coal
(D) Bauxite

132. The city of Bhopal is well-known for its natural and man-made waterbodies. Which of these is a prominent Ramsar site in Bhopal?
(A) Tawa Reservoir
(B) Gandhi Sagar
(C) Indira Sagar
(D) Bhoj Wetland

133. The rock shelters at Bhimbetka were an ideal habitat for prehistoric people primarily because they provided:
(A) Direct access to fertile land for sedentary agriculture.
(B) A reliable source of metallic ores for tools.
(C) Protection from elements and a vantage point for game.
(D) Easy access to the coastline for saltwater fishing.

134. Which of these geoheritage sites in Madhya Pradesh is NOT primarily known for fossils?
(A) Ghughwa Fossil Park
(B) Lameta Ghat, Jabalpur
(C) Narmada Valley sites near Hathnora
(D) Bagh Caves

135. The National Mineral Development Corporation (NMDC) operates the diamond mine at Majhgawan in which district of Madhya Pradesh?
(A) Panna
(B) Satna
(C) Rewa
(D) Chhatarpur

136. Which of the following is the best example of a Rock Monument" as a geotourism attraction in Madhya Pradesh?
(A) The Sanchi Stupa
(B) The Balancing Rock of Jabalpur
(C) The Taj-ul-Masajid in Bhopal
(D) The Gwalior Fort walls

137. The groundwater in the alluvial provinces along the Narmada river is generally found in which type of geological material?
(A) Layers of sand, silt, and gravel
(B) Fractured granite
(C) Vesicular basalt
(D) Cavernous limestone

138. The location of cement industries in the Satna-Rewa-Katni belt of Madhya Pradesh is a direct consequence of the availability of high-quality limestone from the:
(A) Deccan Traps
(B) Gondwana Supergroup
(C) Vindhyan Supergroup
(D) Bundelkhand Gneiss

139. Which of the following statements about the tectonic features of Madhya Pradesh is incorrect?
(A) The Narmada Valley is a graben.
(B) The Satpura range is a horst.
(C) The Narmada-Son lineament is a major zone of weakness.
(D) The entire state is part of a tectonically stable, inactive shield.

140. A key difference between the Ghughwa Fossil Park and the fossil sites in the Narmada Valley is that:
(A) Ghughwa has plant fossils, while Narmada Valley is known for animal and hominid fossils.
(B) Ghughwa has Mesozoic fossils, while Narmada Valley has Paleozoic fossils.
(C) Ghughwa is a man-made park, while Narmada Valley is entirely natural.
(D) Ghughwa fossils are much younger than Narmada Valley fossils.

141. The 'wise use' principle of the Ramsar Convention encourages:
(A) The complete prohibition of human access to the wetland.
(B) Sustainable utilization of wetland resources for humans and ecosystems.
(C) The conversion of wetlands into deep reservoirs for boating.
(D) Draining the wetland to create real estate.

142. The murals of the Bagh Caves are significant from a geo-archaeological perspective because they provide insight into the material culture and life during which period?
(A) Prehistoric Stone Age
(B) Harappan Civilization
(C) Mughal Empire

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(A) An excellent aquifer
(B) An aquitard or aquifuge
(C) A high-porosity medium
(D) An unconsolidated sediment

104. The Bagh Caves, a geoarchaeological site, are a series of rock-cut monuments located on the banks of which river?
(A) Narmada
(B) Chambal
(C) Baghani
(D) Betwa

105. Consider the following statements:
Statement I : The Ghughwa Fossil Park contains fossils of marine animals like trilobites.
Statement II : The fossils at Ghughwa are primarily of terrestrial plants, including petrified palms, dicots, and monocots, from the late Cretaceous period.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is incorrect, but Statement II is correct.
(D) Statement I is correct, but Statement II is incorrect.

106. The HINDALCO aluminium plant at Renukoot (Uttar Pradesh) heavily relies on bauxite supplied from which region of Madhya Pradesh?
(A) Malwa Plateau
(B) Narmada Valley
(C) Amarkantak-Rewa belt
(D) Chambal region

107. Match the following items in List I with those in List II:
List I: (Stratigraphic Unit) P. Deccan Traps, Q. Gondwana Supergroup, R. Vindhyan Supergroup, S. Archaean
List II: (Characteristic Rock Type/Resource) 1. Sandstone, Limestone, 2. Gneiss, Granite, 3. Basalt, 4. Coal, Sandstone
Choose the correct answer from the options given below:
(A) P-3, Q-4, R-1, S-2
(B) P-4, Q-3, R-2, S-1
(C) P-3, Q-1, R-4, S-2
(D) P-2, Q-4, R-1, S-3

108. The main threat to the paintings in the Bhimbetka rock shelters is:
(A) Tectonic activity
(B) Volcanic eruptions
(C) Weathering, water seepage, and anthropogenic factors like vandalism.
(D) River erosion

109. Which of the following is NOT a designated Ramsar site in Madhya Pradesh?
(A) Sirpur Wetland
(B) Sakhya Sagar
(C) Bhoj Wetland
(D) Pench National Park

110. Given below are two statements, one is labelled as Assertion (A) and the other as Reason (R):
Assertion (A) : Exploration for new mineral deposits in Madhya Pradesh is often guided by the state's stratigraphic map.
Reason (R) : Different mineral deposits are typically associated with specific geological formations and rock types (e.g., coal in Gondwanas, limestone in Vindhyans).
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

111. What was the primary purpose for the creation of the ancient Bhojtal (Upper Lake) in the 11th century by Raja Bhoj?
(A) To provide drinking and irrigation water for the city of Bhojpal
(B) To create a naval base
(C) To create a large-scale fishing pond
(D) As a moat for a large fort

112. The presence of 'dykes' and 'sills' in the geological formations of Madhya Pradesh is evidence of:
(A) Sedimentary deposition in a marine environment.
(B) Igneous intrusive activity.
(C) Glacial scouring and deposition.
(D) Wind erosion and dune formation.

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(B) The growth rings and cellular structure of the trees.
(C) The flowers and fruits they bore.
(D) The insects that lived on them.

155. The structural trend of the Narmada rift valley is predominantly:
(A) North-South
(B) East-West
(C) Northwest-Southeast
(D) Northeast-Southwest

156. The Chambal Valley is famous for its 'badland topography' or ravines. This is an example of extreme:
(A) Glacial erosion
(B) Wind deposition
(C) Gully erosion by fluvial processes
(D) Volcanic collapse

157. Which of the following mineral-based industries has the least presence in Madhya Pradesh, despite the state's rich mineral portfolio?
(A) Cement
(B) Thermal Power
(C) Petroleum Refining
(D) Alumina Production

158. The study of ancient waterbodies like the Bhojtal and the numerous tanks in Bundelkhand falls under the purview of:
(A) Paleoclimatology
(B) Historical hydrogeology or hydro-archaeology
(C) Oceanography
(D) Glaciology

159. The caves at Bagh are an example of what type of geoarchaeological site?
(A) A natural cave system used for habitation.
(B) A series of man-made rock-cut monastic dwellings.
(C) A fortified underground city.
(D) A prehistoric burial site.

160. The success of a Geopark depends on the integration of three key components:
(A) Mining, Industry, and Transportation
(B) Conservation, Education, and Sustainable Development (Geotourism)
(C) Agriculture, Forestry, and Fishing
(D) Research, Secrecy, and Exclusion

161. The basement rocks underlying most of the stratigraphic units in Madhya Pradesh belong to which geological eon?
(A) Phanerozoic
(B) Proterozoic
(C) Archaean
(D) Hadean

162. Consider the following statements:
Statement I : The Panna region is the only area in India where diamonds are currently mined on a commercial scale.
Statement II : The diamonds are sourced from Precambrian-age kimberlite pipes.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct, but Statement II is incorrect.
(D) Statement I is incorrect, but Statement II is correct.

163. The primary source of groundwater recharge in most of Madhya Pradesh is:
(A) Seepage from exotic rivers
(B) Melting of glaciers
(C) Subterranean flows from the Himalayas
(D) Infiltration of rainfall

164. The paintings at Bhimbetka, which depict scenes of hunting, dancing, and communal life, provide valuable information for which field of study?
(A) Political Science
(B) Paleo-anthropology and Archaeology
(C) Economic forecasting
(D) Marine biology

165. The presence of 'Rock Monuments' like Inselbergs or Tors in areas like Bundelkhand is due to:
(A) Deposition by wind
(B) Differential weathering and erosion of granitic rocks
(C) Human construction
(D) Recent volcanic activity

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different eras and styles.
(D) The art is carved into the rock rather than painted.

123. Given below are two statements, one is labelled as Assertion (A) and the other as Reason (R):
Assertion (A) : The Gondwana Supergroup is absent in the northernmost parts of Madhya Pradesh, such as the Gwalior region.
Reason (R) : These northern areas are dominated by the much older Vindhyan Supergroup and the Bundelkhand Gneissic Complex, on which the Gondwanas were not deposited.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

124. The 'Malwa Traps' is another name for which major stratigraphic unit in Madhya Pradesh?
(A) Vindhyan Supergroup
(B) Gondwana Supergroup
(C) Lameta Formation
(D) Deccan Traps

125. The presence of both natural waterbodies and numerous man-made ancient waterbodies highlights a long history of what in Madhya Pradesh?
(A) Human interaction and management of water resources
(B) A complete lack of surface water
(C) A society that relied solely on groundwater
(D) A climate that was always water-surplus

126. If a company wants to set up a large-scale steel plant in Madhya Pradesh, its success would be limited by the state's relative scarcity of which key raw material?
(A) Limestone
(B) High-grade iron ore
(C) Coal
(D) Water

127. Consider the following statements about the geodiversity of Madhya Pradesh:
1. It ranges from some of the oldest Archaean rocks to recent alluvial deposits.
2. It includes unique tectonic features like the Narmada Rift Valley.
3. The geodiversity is uniform across the entire state, with no regional variation.

Which of the above statement(s) is/are correct?
(A) 1 only
(B) 1 and 2 only
(C) 2 and 3 only
(D) 1, 2 and 3

128. The designation of Sirpur, Yashwant Sagar, and Sakhya Sagar as Ramsar sites in 2022 significantly increased the number of such recognized wetlands in Madhya Pradesh. This reflects:
(A) A recent discovery of these waterbodies.
(B) Increased recognition of the ecological importance of these man-made and natural wetlands.
(C) A political decision with no ecological basis.
(D) The drying up of all other waterbodies in the state.

129. The fossil of 'Raja Narmadensis', a large carnivorous dinosaur, was discovered in the rocks of the:
(A) Vindhyan Supergroup
(B) Lameta Formation near Jabalpur
(C) Gondwana Supergroup near Pachmarhi
(D) Deccan Traps near Mandu

130. Consider the following statements:
Statement I : The Narmada and Tapti rivers flow in parallel rift valleys.
Statement II : The block of land between these two rivers, the Satpura Range, is a classic example of a horst.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct, but Statement II is incorrect.
(D) Statement I is incorrect, but Statement II is correct.

131. The primary economic importance of the Gondwana stratigraphic units in Madhya Pradesh is their vast resource of:
(A) Diamond
(B) Limestone

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(B) Preventing all forms of development.
(C) Promoting mining in sensitive areas.
(D) Keeping the sites secret from the public.

179. The discovery of the 'Narmada Man' (Homo erectus) fossil at Hathnora is significant because it represents:
(A) The earliest dinosaur fossil in India.
(B) The only hominid fossil from the Middle Pleistocene found in the subcontinent.
(C) A modern human skeleton buried ceremonially.
(D) A fossil of an early primate, not a hominid.

180. Which of the following is NOT a direct threat to the hydrogeology and waterbodies of Madhya Pradesh?
(A) Over-extraction of groundwater
(B) Pollution from industrial and domestic sources
(C) Controlled, sustainable geotourism
(D) Siltation of reservoirs and lakes

181. The term 'horizontality' principle in stratigraphy is well demonstrated by the largely undisturbed, flat-lying beds of the:
(A) Deccan Traps
(B) Vindhyan Supergroup
(C) Folded Archaean rocks
(D) Faulted Gondwana sediments

182. Which city in Madhya Pradesh is known as the 'Manganese City' due to its proximity to the Bharveli mines?
(A) Balaghat
(B) Jabalpur
(C) Indore
(D) Gwalior

183. Consider the following statements:
Statement I : The Ramsar Convention is an international treaty for the conservation and sustainable use of wetlands.
Statement II : Madhya Pradesh has no sites designated under this convention.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is correct, but Statement II is incorrect.
(D) Statement I is incorrect, but Statement II is correct.

184. The establishment of the Ghughwa Fossil Park was primarily to:
(A) Create a botanical garden with living plants.
(B) Protect and preserve the in-situ paleobotanical fossils.
(C) Provide a site for zoological research.
(D) Develop a new coal mine.

185. The Son-Narmada-Tapti lineament system is a zone that has been tectonically active since:
(A) The Holocene epoch
(B) The Precambrian era
(C) The last 100 years
(D) The year 2000

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186. The largest mineral-based industry in Madhya Pradesh, in terms of bulk material consumed, is arguably the:
(A) Diamond polishing industry
(B) Copper smelting industry
(C) Cement industry
(D) Electronics industry

187. The art of the Bagh Caves, which includes paintings of Jataka tales and secular scenes, is primarily:
(A) Religious and Buddhist in theme
(B) Political and propagandistic
(C) A mix of Buddhist religious and courtly secular themes
(D) Exclusively depicting flora and fauna

188. A major hydrogeological problem in the hard-rock crystalline province of Bundelkhand is:
(A) Excessive waterlogging throughout the year.
(B) Low storage capacity of aquifers and dependency on fracture systems.
(C) High levels of arsenic contamination.
(D) Seawater intrusion.

189. A key requirement for a site to be considered a 'National Geopark' is:
(A) It must contain significant geological heritage and a plan for sustainable management.
(B) It must have at least one active volcano.
(C) It must be located within a capital city.
(D) It must be completely inaccessible to the

(D) Gupta-Vakataka period (circa 5th-6th century AD)

143. From a geological standpoint, the diamonds of Panna are found in:
(A) Volcanic pipes of kimberlite and conglomerate deposits.
(B) Alluvial deposits of the Narmada river.
(C) Coal seams of the Gondwana Supergroup.
(D) The basalt flows of the Deccan Traps.

144. In hydrogeological terms, the Deccan Basalt acts as a good aquifer only when it is:
(A) A massive, compact, and unjointed flow.
(B) Weathered, vesicular, or fractured.
(C) Covered by a thick layer of clay.
(D) At a very high temperature.

145. What makes Bhimbetka a site of outstanding universal value" leading to its UNESCO World Heritage status?
(A) The density and long duration of prehistoric rock art.
(B) The presence of massive state-wide bauxite reserves.
(C) Its strategic location for historical military defense.
(D) The presence of unique Precambrian marble formations.

146. A geologist studying the stratigraphy of the Satpura basin would primarily be investigating which rock sequence?
(A) Vindhyan Supergroup
(B) Gondwana Supergroup
(C) Bundelkhand Gneiss
(D) Marwar Supergroup

147. Which of these waterbodies in Madhya Pradesh is a man-made reservoir created by a dam, and not an ancient waterbody or a natural lake designated as a Ramsar site?
(A) Bhojtal
(B) Sakhya Sagar
(C) Tawa Reservoir
(D) Sirpur Lake

148. The term 'geodiversity' refers to:
(A) The variety of life forms in a region.
(B) The variety of geological, geomorphological, and soil features and processes.
(C) The diversity of human cultures in a geographical area.
(D) The number of different mineral mines in a state.

149. The age of the Deccan Traps eruptions, which covered a large part of Madhya Pradesh, coincides with which major global event?
(A) The beginning of the Ice Age
(B) The Cambrian explosion
(C) The extinction of the dinosaurs at the Cretaceous-Paleogene boundary
(D) The formation of the Himalayas

150. A major challenge for promoting geotourism in Madhya Pradesh is:
(A) Balancing tourism development with the need for site conservation.
(B) The total lack of sites with significant geological importance.
(C) The state's complete lack of modern connectivity and transport.
(D) A fundamental lack of interest from the local state population.

151. Which stratigraphic unit is the primary source for flagstones and roofing slate in parts of Madhya Pradesh?
(A) Deccan Traps
(B) Upper units of the Vindhyan Supergroup
(C) Gondwana coal seams
(D) Alluvial deposits

152. The copper ore extracted from the Malanjkhand mines is primarily of which type?
(A) Native Copper
(B) Chalcopyrite in quartz reefs
(C) Bauxite
(D) Malachite and Azurite in limestone

153. The Sirpur Lake in Indore, a Ramsar site, is a significant habitat for:
(A) Migratory birds
(B) Saltwater crocodiles
(C) Marine turtles
(D) Snow leopards

154. The fossilized tree trunks at Ghughwa National Park are so well-preserved that they allow for the study of:
(A) The DNA of ancient trees.

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List I: (Ancient Waterbody/Feature) P. Bhojtal, Q. Sakhya Sagar, R. Sirpur Lake, S. Yashwant Sagar
List II: (Modern Location/City) 1. Shivpuri, 2. Indore, 3. Bhopal, 4. Indore
Choose the correct answer from the options given below:
(A) P-3, Q-1, R-4, S-2
(B) P-3, Q-1, R-2, S-4
(C) P-1, Q-3, R-2, S-4
(D) P-3, Q-2, R-1, S-4

95. All the following are major stratigraphic units found in Madhya Pradesh EXCEPT:
(A) Archaean Complex
(B) Vindhyan Supergroup
(C) Gondwana Supergroup
(D) Siwalik Supergroup

96. A government plan aims to promote mineral-based industries in the Baghelkhand region of MP. Which industries would be the most logical to prioritize based on the region's known mineral wealth?
(A) Coal-based power generation and cement
(B) Diamond cutting and copper smelting
(C) Bauxite refining and manganese processing
(D) Granite polishing and IT hardware manufacturing

97. Given below are two statements, one is labelled as Assertion (A) and the other as Reason (R):
Assertion (A) : The Narmada Valley is a seismically active zone.
Reason (R) : It is a deep-seated fault zone that is subject to periodic reactivation due to intra-plate stresses in the Indian subcontinent.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

98. The 'Rock Monuments' of Madhya Pradesh, such as the balancing rock at Jabalpur, are examples of:
(A) Features created by human carving.
(B) Unique landforms created by natural processes of weathering and erosion.
(C) Structures built to worship rocks.
(D) Blocks of rock transported by glaciers.

99. Which one of the following is a man-made ancient waterbody of Madhya Pradesh?
(A) Mun Sagar tank, Dhar
(B) Patalpani waterfalls
(C) Dhuandhar falls
(D) The source of river Tapti

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100. Arrange the following geological time units associated with Madhya Pradesh's geology from oldest to most recent.
1. Proterozoic (Vindhyan deposition)
2. Cretaceous (Deccan Eruption begins)
3. Permo-Carboniferous (Gondwana deposition begins)
4. Archaean (Bundelkhand Craton formation)
Select the correct answer using the code given below:
(A) 4, 1, 3, 2
(B) 1, 4, 3, 2
(C) 4, 3, 1, 2
(D) 2, 3, 1, 4

101. Consider the following statements about the mineral resources of Madhya Pradesh:
1. The state holds a monopoly on the production of all minerals in India.
2. It is the sole producer of diamonds in India.
3. It is one of the leading producers of manganese and copper.
Which of the above statement(s) is/are correct?
(A) 1 only
(B) 2 and 3 only
(C) 1 and 3 only
(D) 1, 2 and 3

102. The tectonic feature known as the Narmada-Son Lineament (NSL) is significant because it:
(A) Marks the northern boundary of the Indian subcontinent.
(B) Divides the Indian subcontinent into two distinct geological blocks.
(C) Is the location of the highest mountain ranges in India.
(D) Is a modern feature formed in the last century.

103. From a hydrogeological perspective, the hard, unweathered granite of the Bundelkhand Gneissic Complex would be classified as:

166. Which of the following is NOT a significant mineral resource of Madhya Pradesh?
(A) Coal
(B) Manganese
(C) Limestone
(D) Uranium

167. Sakhya Sagar in Shivpuri, now a Ramsar site, is a:
(A) Natural saline lake
(B) Man-made reservoir created on the Manier river
(C) Glacial tarn
(D) Volcanic crater lake

168. The study of fossils found in the Narmada Valley primarily helps in understanding the evolution of which kind of fauna?
(A) Cenozoic mammals and hominids
(B) Mesozoic marine reptiles
(C) Paleozoic trilobites
(D) Early Cambrian soft-bodied organisms

169. What type of tectonic force is responsible for the formation of a graben like the Narmada Valley?
(A) Tensional force
(B) Compressional force
(C) Shear force
(D) Torsional force

170. A large part of the Malwa plateau is covered by 'Black Cotton Soil' (Regur). This soil is a direct weathering product of which parent rock?
(A) Vindhyan Sandstone
(B) Gondwana Shale
(C) Deccan Basalt
(D) Bundelkhand Gneiss

171. The district of Sidhi and Singrauli in Madhya Pradesh are part of a major basin known for its vast deposits of:
(A) Bauxite
(B) Coal
(C) Copper
(D) Diamond

172. The conservation of man-made ancient waterbodies is important for:
(A) Understanding historical water management techniques and their potential application today.
(B) Only aesthetic and tourism purposes.
(C) Converting them into modern swimming pools.
(D) Filling them up to create land for housing.

173. The 'Dhuandhar Falls' at Bhedaghat is a prime example of what geomorphological feature?
(A) A waterfall created by the Narmada river plunging over resistant marble rocks.
(B) A man-made cascade.
(C) A river capture point.
(D) A spring emerging from a cliff.

174. Which of the following constitutes a major challenge to the preservation of the Bagh Caves?
(A) The poor quality of the original paintings.
(B) The risk of volcanic eruption.
(C) Over-excavation by archaeologists.
(D) The friable nature of the sandstone in which they are carved and water percolation.

175. Madhya Pradesh's prospect as a major hub for geotourism is based on its:
(A) Diverse and accessible geological formations, fossil sites, and landforms.
(B) Long coastline and beaches.
(C) High snow-capped mountains and glaciers.
(D) Large desert expanses with sand dunes.

176. Identify the correct pair of a stratigraphic unit and its approximate geological age.
(A) Deccan Traps - Precambrian
(B) Vindhyan Supergroup - Mesozoic
(C) Gondwana Supergroup - Paleozoic to Mesozoic
(D) Archaean Gneiss - Cenozoic

177. The industrial town of Pithampur near Indore is a major manufacturing hub, but its mineral-based industries would largely depend on resources transported from other parts of the state, as the local geology is dominated by:
(A) Gondwana coal measures
(B) Vindhyan limestones
(C) Deccan Traps (Basalt)
(D) Diamondiferous kimberlites

178. The identification and protection of Geoheritage sites in Madhya Pradesh is crucial for:
(A) Scientific research, education, and fostering a sense of geological heritage.

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113. The most significant outcome of recognizing a site under the Ramsar Convention is the promotion of:
(A) 'Wise use' of the wetland's resources.
(B) Conversion of the wetland into agricultural land.
(C) Unrestricted tourism and construction.
(D) Introduction of exotic fish species.

114. Consider the following statements about the fossil parks of Madhya Pradesh:
1. Ghughwa Fossil Park is known for its collection of dinosaur eggs.
2. The fossils at Ghughwa are mostly petrified plant specimens.
3. The Lameta Ghat area near Jabalpur is famous for dinosaur fossils.

Which of the above statement(s) is/are correct?
(A) 1 and 3 only
(B) 2 and 3 only
(C) 1 and 2 only
(D) 1, 2 and 3

115. From a geotourism perspective, the marble rocks gorge at Bhedaghat is a result of:
(A) The Narmada river cutting through a belt of Precambrian marble.
(B) A volcanic fissure erupting marble.
(C) Human quarrying activity on a massive scale.
(D) A meteorite impact crater.

116. Which of the following districts is NOT part of the major coal-bearing regions of Madhya Pradesh?
(A) Singrauli
(B) Shahdol
(C) Umaria
(D) Panna

117. Identify the incorrect statement regarding the hydrogeology of Madhya Pradesh.
(A) Groundwater quality is a concern in some areas due to high fluoride or salinity.
(B) Aquifer systems are universally interconnected throughout all rock formations.
(C) The state lacks a uniform and easily accessible deep aquifer.
(D) Artificial recharge structures are being promoted to improve groundwater levels.

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118. The paintings in the Bagh Caves, though located in rock-cut shelters, are primarily executed on which surface?
(A) On a prepared surface of mud-plaster (tempera)
(B) Directly on the rough rock surface
(C) On wooden panels inserted into the walls
(D) As mosaic tiles

119. A proposal to establish a 'Lameta Geopark' in Madhya Pradesh would be centered around:
(A) Preserving the unique diamond-bearing geological formations.
(B) Showcasing the history of coal mining in the state.
(C) Conserving dinosaur fossil sites and marble rock gorges.
(D) Protecting the ancient rock art of the Chambal valley.

120. Match the following items in List I with those in List II:
List I: (Mineral-Based Plant) P. Cement Plant, Q. Thermal Power Plant, R. Copper Smelter, S. Diamond Mine
List II: (Primary Raw Material) 1. Coal, 2. Kimberlite / Lamproite Rock, 3. Copper Ore (Chalcopyrite), 4. Limestone
Choose the correct answer from the options given below:
(A) P-4, Q-2, R-1, S-3
(B) P-1, Q-4, R-3, S-2
(C) P-4, Q-1, R-3, S-2
(D) P-2, Q-3, R-1, S-4

121. The Son River, a major tributary of the Ganga, originates near the source of the Narmada at Amarkantak and flows east. This drainage pattern is strongly influenced by:
(A) The alignment of the Narmada-Son Lineament.
(B) The slope of the Deccan Traps.
(C) The Himalayan orogeny.
(D) Coastal erosion processes.

122. Which of the following is a key characteristic of the rock art at Bhimbetka?
(A) The subjects are exclusively religious deities.
(B) All paintings are monochrome (single color).
(C) There is a superposition of paintings from

public.

190. The discovery of dinosaur nests and a large number of eggs in the Lameta beds of the Narmada Valley suggests that the area was:
(A) A nesting and breeding ground for dinosaurs.
(B) A high-altitude glacial region.
(C) A deep marine environment.
(D) An area of active volcanism at the time.

191. The presence of stromatolites in the Vindhyan Supergroup is significant evidence for:
(A) The existence of large animals in the Proterozoic.
(B) The presence of early life (cyanobacteria) in shallow marine environments.
(C) The occurrence of glaciation.
(D) The beginning of flowering plants.

192. Which mineral, found in Madhya Pradesh, is essential for the production of dry cell batteries and ferro-alloys?
(A) Bauxite
(B) Manganese
(C) Limestone
(D) Diamond

193. The phenomenon of 'lake eutrophication' is a major threat to which prominent waterbody in Madhya Pradesh?
(A) The Narmada River
(B) The Bhoj Wetland (Upper Lake)
(C) The Patalpani waterfall
(D) The Tapti River source

194. The 'Patalkot' region in Chhindwara district, a deep valley, is an example of what type of geomorphological feature?
(A) A deeply eroded structural valley
(B) A volcanic crater
(C) A glacial cirque
(D) A meteorite impact site

195. The rock shelters of Bhimbetka are composed of which rock type, providing a durable 'canvas' for prehistoric artists?
(A) Sandstone
(B) Basalt
(C) Granite
(D) Marble

196. Which tectonic feature separates the Vindhyan mountains from the Satpura mountains in Madhya Pradesh?
(A) The Great Boundary Fault
(B) The Main Central Thrust
(C) The Narmada Rift Valley
(D) The Chambal Valley

197. The term 'mineral-based industries' refers to industries that:
(A) Use minerals as their primary raw material.
(B) Sell polished rocks as souvenirs.
(C) Manufacture mining equipment.
(D) Are owned and operated by geologists.

198. The 'Lower Lake' of Bhopal, a part of the Bhoj Wetland ecosystem, is believed to have been created in which period?
(A) During the reign of Raja Bhoj (11th Century)
(B) During the Mughal period (18th Century)
(C) By the British in the 19th Century
(D) As part of a post-independence project in the 20th Century

199. From a geoarchaeological perspective, the continuous sequence of stone tool industries found in the Narmada Valley, from Lower Paleolithic to Mesolithic, is crucial for:
(A) Understanding the evolution of technology and human adaptation over millennia.
(B) Finding precious gems.
(C) Determining the age of the Deccan Traps.
(D) Locating the best sites for modern dam construction.

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200. The primary purpose of establishing 'Fossil Parks' in Madhya Pradesh is:
(A) In-situ and ex-situ conservation of paleontological heritage for science and education.
(B) To provide a recreational area for picnics.
(C) To quarry the fossil-bearing rock for construction.
(D) To create a fictional dinosaur-themed amusement park.

201. The stratigraphic unit known as the Mahakoshal Group, found along the Narmada-Son lineament, consists of:
(A) Deformed and metamorphosed volcanic and sedimentary rocks.

(D) Prehistoric rock art along its banks.

224. The petrified wood at Ghughwa Fossil Park belongs to trees that grew during the time of the:
(A) Dinosaurs
(B) First humans
(C) British Raj
(D) Ice Age mammals

225. The Satpura horst is a block mountain that was uplifted between which two tectonic features?
(A) The Narmada Graben and the Tapti Graben
(B) The Yamuna River and the Ganga River
(C) The Great Boundary Fault and the Main Central Thrust
(D) The Bay of Bengal and the Arabian Sea

226. Besides coal, the Gondwana sandstones in Madhya Pradesh are also a potential source of:
(A) High-quality building stone
(B) Groundwater and hydrocarbons
(C) Diamonds
(D) Rock salt

227. The most significant contribution of the Bhoj Wetland Ramsar site to the city of Bhopal is:
(A) Regulating the local microclimate and providing a vital water source.
(B) Acting as a barrier to urban expansion.
(C) Providing a large area for waste disposal.
(D) Being a source of construction sand.

228. A geoarchaeological study of Bhimbetka would likely involve analyzing all of the following EXCEPT:
(A) The chemical composition of the pigments used in the paintings.
(B) The stone tools found in the excavated floor deposits.
(C) The geology of the sandstone shelters themselves.
(D) The records of crop yields from surrounding modern farms.

229. The term 'Fossil Park' in the context of Madhya Pradesh refers to a legally protected area primarily for the conservation of:
(A) Paleontological remains
(B) Living animal species
(C) Archaeological artifacts
(D) Rare species of living plants

230. The 'Lameta Formation' is geologically significant as it represents the environment prevailing just before which major geological event?
(A) The onset of the Deccan Traps volcanism
(B) The formation of the Vindhyan Sea
(C) The beginning of the Gondwana sedimentation
(D) The last glacial maximum

231. The Archaean-age rocks of the Bundelkhand Gneissic Complex are a potential source for which industrial mineral/rock?
(A) Dimensional stone (granite)
(B) Coal
(C) Petroleum
(D) High-quality limestone

232. The BALCO aluminium plant in Korba (Chhattisgarh) was initially set up to process bauxite from which nearby region in Madhya Pradesh?
(A) Amarkantak plateau
(B) Panna-Satna region
(C) Malwa plateau
(D) Chambal ravines

233. The over-exploitation of groundwater in hard-rock areas of Madhya Pradesh often leads to the failure of which type of water source?
(A) Dug wells and borewells
(B) Large perennial rivers
(C) Deep sea ports
(D) Rainwater harvesting tanks

234. If you discover a new, previously unknown painting in a rock shelter in the Vindhyan range of Madhya Pradesh, you have found a potential new:
(A) Geoarchaeological site
(B) Geoheritage site
(C) Geopark
(D) Ramsar site

235. The prospect of declaring Jabalpur as India's first 'Geopark' is high due to the presence of:
(A) A unique assemblage of significant geological heritage.
(B) Its current status as the administrative state capital.
(C) Having the largest human population in the

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212. If you are in the Umaria or Shahdol district, you are in a region known for its significant reserves of:
(A) Coal
(B) Diamond
(C) Copper
(D) Bauxite

213. Managing the water levels of the Bhoj Wetland involves balancing the needs of urban water supply with the ecological requirements of the Ramsar site. This is a classic example of:
(A) The 'wise use' concept.
(B) Complete ecosystem destruction.
(C) Ignoring international treaties.
(D) Draining a wetland for agriculture.

214. The rock art at Bhimbetka is primarily found on what part of the rock shelters?
(A) On the inner walls and ceilings, protected from direct rain.
(B) On the floors of the caves.
(C) On the exterior rock faces exposed to the sun.
(D) Buried deep underground.

215. The 'Narmada Man' skull cap is a fossil of which hominid species?
(A) Homo erectus
(B) Homo sapiens
(C) Australopithecus africanus
(D) Neanderthalensis

216. The Great Dyke of Gwalior is a prominent geological feature. What is a 'dyke'?
(A) A sheet-like body of igneous rock that cuts across the bedding of older rocks.
(B) A layer of sedimentary rock.
(C) A man-made defensive wall.
(D) A fold in the earth's crust.

217. The NEPA Limited in Nepanagar, Madhya Pradesh, was the country's first indigenous newsprint manufacturing unit. Its location was influenced by the availability of forest resources and water, but which mineral resource is essential for the large amount of power it requires?
(A) Coal
(B) Bauxite
(C) Limestone
(D) Iron Ore

218. The water quality of which groundwater province in Madhya Pradesh is most susceptible to contamination from agricultural fertilizers and pesticides due to high infiltration rates?
(A) Alluvial provinces
(B) Crystalline hard-rock provinces
(C) Deccan Trap provinces
(D) Vindhyan provinces

219. The geoarchaeological importance of the Bagh Caves is diminished by the fact that:
(A) Many of the original nine caves have collapsed or are in poor condition.
(B) The paintings are modern forgeries.
(C) The site has no historical significance.
(D) The caves are made of indestructible granite.

220. The promotion of geotourism in a region like the Narmada Valley requires careful planning to avoid:
(A) Damaging or allowing the theft of scientifically important fossils.
(B) Educating the public about fossils.
(C) Generating revenue for local communities.
(D) Collaborating with universities for research.

221. The Vindhyan Supergroup is largely devoid of complex multicellular life fossils because it was deposited:
(A) During the Proterozoic eon, before the Cambrian explosion.
(B) During the Cenozoic era, after the mass extinctions.
(C) In a terrestrial, desert environment.
(D) During a period of intense volcanic activity.

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222. The Panna diamond belt is associated with the margins of which major geological unit?
(A) The Vindhyan Basin
(B) The Deccan Traps
(C) The Gondwana Basin
(D) The Himalayan Foredeep

223. What is a significant man-made threat to the natural flow and ecology of rivers like the Narmada in Madhya Pradesh?
(A) The construction of a series of large dams.
(B) Seasonal monsoons.
(C) The presence of marble at Bhedaghat.

247. The ochre deposits of Satna, used in the paint industry, are associated with which stratigraphic unit?
(A) Deccan Traps
(B) Gondwana Supergroup
(C) Vindhyan Supergroup
(D) Alluvium

248. Many 'talabs' (tanks) and 'johads' (ponds) in the Bundelkhand region of MP are examples of:
(A) Traditional rainwater harvesting and groundwater recharge structures.
(B) Natural lakes formed by glaciation.
(C) Failed attempts at drilling for oil.
(D) Craters formed by meteorite impacts.

249. Bhimbetka, Bagh Caves, and the Narmada Valley are all crucial sites for understanding the:
(A) Geo-archaeological heritage and deep human history of the region.
(B) Complete industrial history of Madhya Pradesh.
(C) Future seismic risks in the state.
(D) Distribution of mineral wealth.

250. The fossils of Ghughwa, dating back to the late Cretaceous, provide a snapshot of the flora just before the:
(A) K-Pg extinction event that wiped out the dinosaurs.
(B) Start of the Gondwana sedimentation.
(C) Formation of the Vindhyan sea.
(D) Beginning of the last Ice Age.

251. The Sausar Group of rocks in the Chhindwara-Nagpur region are economically important for their deposits of:
(A) Manganese Ore
(B) Diamond
(C) Coal
(D) Bauxite

252. A mineral-based industry like a thermal power plant in Singrauli is a major contributor to the local economy, but also a source of what environmental concern?
(A) Depletion of water resources.
(B) Fly ash pollution and greenhouse gas emissions.
(C) Noise pollution from turbines.
(D) All of the above.

253. The presence of numerous small and large dams and reservoirs in Madhya Pradesh has significantly altered the state's:
(A) Natural hydrogeological regime and river flow patterns.
(B) Political boundaries.
(C) Time zone.
(D) Underlying geology.

254. The reddish and yellow colours used in the Bhimbetka paintings were most likely derived from:
(A) Minerals like ochre and hematite
(B) Plant extracts and flowers.
(C) Imported synthetic dyes.
(D) Animal blood.

255. The concept of geotourism is different from general tourism because it has a strong component of:
(A) Interpretation and education about the geological landscape
(B) Luxury and comfort.
(C) Shopping and entertainment.
(D) High-speed travel.

256. The boundary between the Deccan Traps and the underlying Lameta Formation represents a:
(A) Major unconformity and a significant time gap.
(B) A continuous and uninterrupted sequence of deposition.
(C) A gradual transition from sedimentary to igneous rock.
(D) A political boundary drawn by geologists.

257. The mining of rock phosphate, a key ingredient for fertilizers, occurs in which district of Madhya Pradesh?
(A) Jhabua
(B) Panna
(C) Singrauli
(D) Balaghat

258. What is the most significant ecological service provided by the wetlands of Madhya Pradesh that led to their recognition as Ramsar sites?
(A) Serving as habitat for migratory and resident waterfowl
(B) Providing land for construction.
(C) Generating hydroelectric power.

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entire state.
(D) Being the site of the only operational airport in the state.

236. The Narmada-Tapti rift system is considered to be a 'failed rift', meaning:
(A) It did not continue to spread and develop into an ocean basin.
(B) The rift was not formed properly.
(C) The rivers flowing in it failed to reach the sea.
(D) No minerals were found in it.

237. The soapstone (steatite) deposits in Madhya Pradesh, used in various industries, are found associated with which type of rocks?
(A) Metamorphosed ultramafic rocks
(B) Gondwana sandstones
(C) Deccan basalts
(D) Recent alluvial clays

238. The designation of a wetland as a 'Ramsar Site' helps in attracting what for its conservation and management?
(A) National and international attention, expertise, and funding.
(B) Only local tourists.
(C) Only government employees.
(D) Commercial real estate developers.

239. The most famous painting from the Bagh Caves, which has now been largely lost, depicted a:
(A) Royal procession or a scene of courtly life.
(B) Map of ancient India.
(C) Scene from the Ramayana.
(D) Geological cross-section of the region.

240. The fossils at Ghughwa and the fossils in the Narmada Valley both provide evidence for:
(A) The past climate and environment of the region.
(B) The exact date of the formation of the Himalayas.
(C) The process of diamond formation.
(D) The future weather patterns of Madhya Pradesh.

241. The Bijawar Group is a stratigraphic unit in Madhya Pradesh known for its association with:
(A) Metamorphosed sediments and lavas, sometimes with mineral deposits
(B) Coal and gas
(C) Dinosaur fossils
(D) Recent alluvium

242. The state government's mineral policy for Madhya Pradesh would aim to:
(A) Encourage scientific and sustainable mining while promoting value addition within the state.
(B) Ban all mining activities.
(C) Allow unregulated and unscientific mining.
(D) Export all raw minerals without any processing.

243. A hydrogeological map of Madhya Pradesh would show different colours representing:
(A) Different types of groundwater provinces based on geology.
(B) Different political constituencies.
(C) Different crop zones.
(D) Different temperature zones.

244. The Bagh caves are a set of nine rock-cut monuments, but most are now derelict. The most famous is:
(A) Cave No. 4 (Rang Mahal)
(B) Cave No. 1 (Griha)
(C) Cave No. 7
(D) Cave No. 9

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245. The 'Marble Rocks' at Bhedaghat are chemically composed of:
(A) Calcium Carbonate (Calcite/Dolomite)
(B) Silicon Dioxide (Quartzite)
(C) Iron Oxide (Hematite)
(D) Hydrated Aluminium Silicate (Clay)

246. What is the primary difference between the tectonic setting of the Himalayas and the Narmada Valley?
(A) The Himalayas are a result of compression, while the Narmada Valley is a result of tension.
(B) The Himalayas are a result of tension, while the Narmada Valley is a result of compression.
(C) Both are formed by the same tectonic forces.
(D) The Narmada Valley is volcanic, while the Himalayas are not.

on the shorelines.
(B) Monitoring of water quality and bird populations.
(C) Awareness programs for local communities.
(D) Measures to control invasive species.

294. The continuous record of human occupation at Bhimbetka, spanning the Paleolithic to the historic period, makes it a benchmark site for:
(A) The archaeology of South Asia.
(B) The geology of the Deccan Traps.
(C) The study of marine fossils.
(D) The history of the Mughal empire.

295. The fossils of the Narmada Valley are mostly found in which type of sediments?
(A) Fluvial (river-deposited) gravels and clays
(B) Eolian (wind-blown) sands
(C) Glacial moraines
(D) Deep marine oozes

296. The general east-west alignment of the Satpura range is a direct result of:
(A) The tectonic forces that created the Narmada and Tapti rifts.
(B) The direction of the prevailing winds.
(C) The flow direction of ancient glaciers.
(D) A random geological event.

297. The presence of coal, limestone, bauxite, copper, and manganese makes Madhya Pradesh's industrial landscape potentially dominated by:
(A) Resource-processing and mineral-based industries
(B) Software and IT services
(C) Textile and apparel manufacturing
(D) Tourism and hospitality services

298. The 'step-wells' or 'baolis' found in some parts of Madhya Pradesh are a form of:
(A) Man-made ancient hydrogeological structures to access groundwater
(B) Natural springs
(C) Entrances to underground mines
(D) Ritualistic fire pits

299. A major threat to the physical integrity of the rock art at many sites is:
(A) The growth of lichen and micro-organisms on the rock surface.
(B) Earthquakes and volcanic activity.
(C) The changing of the Earth's magnetic field.
(D) Meteorite impacts.

300. The entire geodiversity of Madhya Pradesh, from its Archaean cratons to its Cenozoic fossils, is a record of the state's journey as part of which larger geological entity?
(A) The North American Plate
(B) The Indian Plate
(C) The Pacific Plate
(D) The Antarctic Plate

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(D) Acting as sites for waste disposal.

259. A key difference between the rock art at Bhimbetka and the murals at Bagh Caves is:
(A) The age of the art, with Bhimbetka being thousands of years older.
(B) The type of rock they are on.
(C) Bhimbetka art is religious, while Bagh art is secular.
(D) There is no significant difference.

260. The discovery of a nearly complete skeleton of a sauropod dinosaur in the Narmada Valley highlights the region's potential as a:
(A) World-class paleontological research area
(B) Prime agricultural zone.
(C) Site for geothermal energy.
(D) Source of high-quality marble.

261. The upper beds of the Vindhyan Supergroup, known as the Bhander Group, are a major source of:
(A) Cement-grade limestone and building stone
(B) High-grade coal.
(C) Iron ore.
(D) Bauxite.

262. The establishment of a large number of 'stone crushers' along highways in Madhya Pradesh is a small-scale mineral-based industry that utilizes which local resource?
(A) Locally quarried rock, often basalt or granite
(B) River sand
(C) Imported marble
(D) Coal dust

263. The low primary permeability of the Deccan Basalt leads to:
(A) High surface runoff and groundwater storage in fractures.
(B) Deep and vast underground reservoirs of water.
(C) Uniform distribution of groundwater across the plateau.
(D) Natural purification of all infiltrating water.

264. The Bagh Caves were intended to serve as:
(A) Monastic retreats (Viharas) for Buddhist monks
(B) Royal palaces.
(C) Fortifications.
(D) Granaries.

265. The unique landscape of Pandav Caves in Pachmarhi, with its carved-out sandstone shelters, is a popular destination that combines elements of:
(A) Geotourism and mythological lore
(B) Urban planning and industrial heritage.
(C) Marine biology and oceanography.
(D) Glacial geology and polar research.

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266. Consider the following statements:
Statement I : The Narmada-Son Lineament is a single, continuous fault line.
Statement II : It is a broad zone of several parallel and en-echelon faults and shear zones.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is incorrect, but Statement II is correct.
(D) Statement I is correct, but Statement II is incorrect.

267. The fireclay deposits found in the Jabalpur and Shahdol regions of Madhya Pradesh are used in which industry?
(A) Refractory and ceramic industry
(B) Food processing
(C) Textile manufacturing
(D) Software development

268. The ancient city of Ujjain, with its tradition of astronomy and the 'Mahakaleshwar Jyotirlinga', is situated on the banks of which significant river?
(A) The Shipra River
(B) The Narmada River
(C) The Tapti River
(D) The Bhojtal Lake

269. The scientific study of rock art, like that at Bhimbetka, requires a multi-disciplinary approach involving archaeology, geology, and:
(A) All of the above
(B) Chemistry (for pigment analysis)
(C) Art history (for stylistic analysis)
(D) Anthropology (for cultural interpretation)

(B) Horizontally bedded sandstones and shales.
(C) Recent alluvial deposits.
(D) Flat-lying basalt flows.

202. The Security Paper Mill at Hoshangabad and the Bank Note Press at Dewas are significant industries, but they are not considered 'mineral-based' in the same way as a cement plant because:
(A) Their primary raw material is not a geological mineral.
(B) They are owned by the government.
(C) They are located in the Malwa region.
(D) They do not use electricity.

203. Which of the following best describes the hydrogeological setting of the Narmada alluvial plain?
(A) A multi-layered system of sand and clay, forming productive aquifers.
(B) A single, deep, hard-rock aquifer.
(C) A region with no significant groundwater resources.
(D) A karst landscape with underground rivers.

204. The preservation of the Bagh Caves has been a challenge due to the weak nature of the parent rock, which is:
(A) Gneiss
(B) Marble
(C) Clay-rich sandstone
(D) Granite

205. The concept of a 'Geopark' is promoted globally by which international organization?
(A) The United Nations Educational, Scientific and Cultural Organization (UNESCO)
(B) The World Bank
(C) The World Health Organization (WHO)
(D) The International Monetary Fund (IMF)

206. Consider the following statements:
Statement I : The Narmada is a much longer river than the Tapti.
Statement II : Both rivers flow through rift valleys and empty into the Arabian Sea.
(A) Both Statement I and Statement II are correct.
(B) Both Statement I and Statement II are incorrect.
(C) Statement I is incorrect, but Statement II is correct.
(D) Statement I is correct, but Statement II is incorrect.

207. Which of the following is mined in Madhya Pradesh and used as a flux in the steel industry and as a source of magnesium?
(A) Gypsum
(B) Dolomite
(C) Pyrite
(D) Rock Salt

208. The Ramsar site 'Sakhya Sagar' in Madhav National Park is ecologically important but is also a:
(A) Man-made reservoir constructed in the early 20th century.
(B) Completely natural lake formed by a landslide.
(C) Sacred hot water spring.
(D) Remnant of an ancient sea.

209. The various styles of paintings in Bhimbetka, from stick-figure hunters to more decorated warriors on horseback, serve as a 'rock canvas' illustrating:
(A) The cultural and technological evolution over thousands of years.
(B) A single day's event.
(C) The geological history of the rocks.
(D) A story from the Mahabharata.

210. A key feature making the Bhedaghat-Lametaghat area a strong candidate for a Geopark is the juxtaposition of:
(A) Precambrian marbles, Cretaceous dinosaur fossils, and Deccan Traps.
(B) A major city and a village.
(C) A desert and a rainforest.
(D) Gold mines and diamond mines.

211. The term 'basement complex' in the geology of Madhya Pradesh refers to:
(A) The ancient Archaean and Proterozoic crystalline rocks upon which younger sediments were deposited.
(B) The youngest alluvial deposits.
(C) The Deccan Trap lava flows.
(D) The foundation of a large building.

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(C) Gondwana Sandstone
(D) Archaean Gneiss

282. Which of these is a byproduct of coal mining in Singrauli that is now being considered for industrial use in construction?
(A) Fly ash
(B) Diamond
(C) Gold
(D) Natural gas

283. The hydrogeological unit of the 'Vindhyan Province' is characterized by moderate groundwater potential primarily controlled by:
(A) The network of joints, fractures, and bedding planes
(B) Primary porosity of the rock
(C) The thickness of the overlying soil
(D) The presence of underground rivers

284. The discovery of Titanosaurus egg clutches in the Lameta Formation of Madhya Pradesh provides evidence of dinosaur:
(A) Herding and nesting behavior
(B) Migratory patterns
(C) Diet
(D) Aquatic adaptations

285. A key management strategy for a proposed Geopark at Bhedaghat would involve:
(A) Developing signages to explain the geological features to visitors.
(B) Banning all tourists from the area.
(C) Encouraging quarrying of the marble rocks.
(D) Filling the Narmada gorge with concrete.

286. The Narmada-Son Lineament (NSL) is a deep-seated crustal feature that has influenced sedimentation and tectonics in central India since:
(A) The Proterozoic era
(B) The last 10,000 years
(C) The British colonial period
(D) The year 2000

287. Which important mineral used in refractory bricks is mined in the Jabalpur-Katni region?
(A) Fireclay
(B) Bauxite
(C) Diamond
(D) Copper

288. The man-made waterbodies designated as Ramsar sites in Madhya Pradesh, like Sirpur and Yashwant Sagar, underscore the idea that:
(A) Artificial wetlands can also develop significant biodiversity and ecological value.
(B) Only natural wetlands can have ecological importance.
(C) All man-made lakes are ecologically dead.
(D) Ramsar sites are only about water storage, not biodiversity.

289. The themes depicted in the Bhimbetka rock art, such as group dancing, hunting, and mother-child figures, provide insight into the:
(A) Social and cultural life of prehistoric people
(B) Economic policies of ancient kingdoms.
(C) Advanced metallurgical techniques.
(D) Navigation methods used for sea voyages.

290. The term 'geoconservation' is central to the idea of a Geopark. It means:
(A) The protection of important geological features from degradation.
(B) Conserving only living organisms.
(C) Storing rock samples in a museum.
(D) Preventing geologists from studying an area.

291. The Deccan Traps are largely horizontal flows, but in the Narmada valley region, they are often tilted or faulted. This indicates:
(A) The area has experienced tectonic activity after the eruption of the lavas
(B) The lava flowed downhill.
(C) The lava was of different viscosity.
(D) The area was covered by an ocean after the eruption.

292. The Government of India's 'Diamond Parks' or 'Special Economic Zones' for gems and jewellery in cities like Indore are an attempt to promote what part of the mineral industry?
(A) Value addition through cutting, polishing, and manufacturing
(B) Mining and exploration
(C) Smelting and refining
(D) Transportation of raw diamonds

293. The management plan for a Ramsar site in Madhya Pradesh would typically include all of the following EXCEPT:
(A) Promoting uncontrolled urban development

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270. A major future prospect for geotourism in Madhya Pradesh is the development of curated 'geotrails'. What is a geotrail?
(A) A designated route that guides visitors through a series of interesting geological sites
(B) A trail for transporting heavy geological equipment.
(C) A railway line built specifically for geologists.
(D) A virtual reality simulation of a geological tour.

271. The oldest geological formations exposed in Madhya Pradesh, the Archaean rocks, are typically:
(A) Highly metamorphosed and crystalline
(B) Unmetamorphosed and rich in fossils.
(C) Composed of soft clay and silt.
(D) Volcanic ash deposits.

272. The term 'slate pencil' industry in Mandsaur is based on the quarrying of a specific type of rock from which geological sequence?
(A) Vindhyan Supergroup
(B) Gondwana Supergroup
(C) Deccan Traps
(D) Alluvium

273. The primary role of the State Groundwater Board or equivalent body in Madhya Pradesh is to:
(A) Monitor, assess, and manage the state's groundwater resources.
(B) Own all the groundwater and sell it commercially.
(C) Prevent rainfall from infiltrating into the ground.
(D) Focus only on surface water projects.

274. The main challenge in preserving the prehistoric art at Bhimbetka from a geological perspective is:
(A) The slow process of weathering and exfoliation of sandstone.
(B) The rapid erosion of the hard quartzite rock.
(C) The threat of impending volcanic eruption.
(D) The movement of glaciers.

275. The fossil record of the Narmada Valley is particularly rich for which geological period?
(A) Pleistocene
(B) Precambrian
(C) Permian
(D) Triassic

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276. The tectonic activity along the Narmada-Tapti zone is driven by:
(A) Stresses from the Indian plate's collision with the Eurasian plate.
(B) The gravitational pull of the moon.
(C) The melting of Himalayan glaciers.
(D) Oceanic currents in the Arabian Sea.

277. The limestone found in the Vindhyan Supergroup is of what origin?
(A) Chemical and biogenic precipitate in a shallow sea
(B) Volcanic
(C) A product of wind deposition
(D) Metamorphosed coal

278. An example of a man-made ancient waterbody in the Bundelkhand region would be a:
(A) Large tank or 'sagar' created by building an earthen dam
(B) Natural spring
(C) Glacial lake
(D) River flowing from the Himalayas

279. Why are the Bagh Caves considered a significant geoarchaeological site despite the poor preservation of some caves?
(A) They represent a rare example of rock-cut architecture and Gupta-era painting in Central India.
(B) They contain the world's largest diamond.
(C) They are the source of the Narmada river.
(D) They have yielded a complete T-Rex skeleton.

280. The Ghughwa Fossil Park is an open-air museum where visitors can see:
(A) Petrified tree trunks lying in the positions they were found
(B) Replicas of fossils made from plastic.
(C) A live display of Cretaceous-era plants.
(D) Animatronic dinosaurs.

281. Which stratigraphic unit forms the bedrock for the Bhimbetka rock shelters?
(A) Bhander Group of the Vindhyan Supergroup
(B) Deccan Basalt

ANSWERS

1. (B) Vindhyan Supergroup
The Vindhyan Supergroup is a major Proterozoic stratigraphic unit in India, particularly prominent across central and northern Madhya Pradesh. This sequence is renowned for its thick sedimentary layers, including sandstone, shale, and limestone. It records significant geological history and provides essential resources for the construction and cement industries, representing a stable and expansive basin formation within the regional landscape.

2. (A) Both Statement I and Statement II are correct.
The Narmada River flows through a prominent west-trending rift valley, which is a significant tectonic feature in India. This structural graben was formed by faulting within the Indian plate. Its existence influences the drainage pattern and geological evolution of Madhya Pradesh, making it a critical area for studying intra-plate tectonic activity and the state's historical seismic movements.

3. (C) Copper
The Malanjkhand mine, located in the Balaghat district, is one of India's largest and most significant open-cast copper mines. Operated by Hindustan Copper Limited, it exploits a large granitic ore body containing primary copper mineralization. The site is a major contributor to the state's mineral economy and is essential for meeting national industrial copper demands across various sectors.

4. (D) Coastal alluvial provinces
Madhya Pradesh is a landlocked state in central India and does not possess a coastline. While it features crystalline, Gondwana, and Vindhyan groundwater provinces based on its diverse interior geology, it lacks coastal alluvial provinces. These are typically found in maritime states along the Bay of Bengal or the Arabian Sea, involving different sediment deposition processes and hydrogeological characteristics.

5. (C) Raisen
The Bhimbetka Rock Shelters are located within the Raisen district of Madhya Pradesh. Situated on the southern edge of the Vindhya Range, this UNESCO World Heritage site features massive sandstone outcrops. These natural shelters contain a wealth of prehistoric rock art, providing evidence of continuous human habitation from the Paleolithic period through the Mesolithic and into historical times.

6. (A) Both A and R are true and R is the correct explanation of A.
Madhya Pradesh holds a prominent position in India's mineral sector as the leading producer of diamonds. The Majhgawan mine in the Panna district serves as the primary commercial source for these gemstones. Geologically, these diamonds are found in kimberlite pipes and associated conglomerates, making the Panna region the unique hub for diamond extraction and production in the country.

7. (D) A protected area showcasing geological heritage for conservation.
A Geopark is a unified geographical area where sites and landscapes of international geological significance are managed with a holistic concept of protection, education, and sustainable development. In Madhya Pradesh, the prospect of developing Geoparks aims to conserve unique geodiversity while promoting geotourism. This approach integrates geological heritage with the natural and cultural history of the specific regional environment.

8. (A) It flows parallel to the Narmada through a similar rift structure.
The Tapti River flows westward through a well-defined rift valley or graben structure, similar to the Narmada River. These two rivers are unique among major peninsular streams for their westward flow, which is controlled by pre-existing tectonic faults. The Satpura Range acts as a horst, separating these two parallel tectonic troughs that define the region's structural landscape.

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76. (B) Along the major river valleys like the Narmada and Chambal.
Alluvial groundwater provinces in Madhya Pradesh are located along the extensive floodplains and valleys of major rivers like the Narmada, Chambal, and Son. These provinces consist of unconsolidated sediments such as sand, silt, and gravel deposited by river action. These porous and permeable materials form productive aquifers that can store large quantities of groundwater, making these valleys critical regions for agricultural development and stable water supplies in the state.

77. (A) Primary source of drinking water.
The Bhoj Wetland, specifically the Upper Lake, is a critical infrastructure asset for Bhopal as it provides a major portion of the city's drinking water. As a designated Ramsar site, its ecological health is directly linked to the urban water security of the capital. Maintaining the water quality and preventing pollution in this ancient reservoir are essential for both sustaining the local population and preserving the diverse wetland ecosystem.

78. (A) Environmentally responsible travel to natural areas to enjoy and appreciate geological features.
Geotourism in Madhya Pradesh is a specialized form of tourism that focuses on the state's geological heritage. It promotes travel to sites like Bhedaghat or Ghughwa to appreciate landforms, rocks, and fossils in an environmentally responsible manner. The aim is to foster an understanding of Earth's processes while ensuring that fragile geological features are conserved. This approach provides sustainable economic benefits to local communities without compromising the integrity of the geological sites.

79. (A) Proterozoic
The Vindhyan Supergroup is a massive sedimentary sequence that was deposited during the Proterozoic Eon. These rocks represent a long period of Earth's history, predating the explosion of complex multicellular life in the Cambrian. The age of this unit is fundamental for understanding the early development of the Indian crust and the formation of stable sedimentary basins that have remained largely undisturbed for over a billion years in central India.

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80. (A) 1, 2, 3, 4
The sequence of these events follows the geological timeline of Madhya Pradesh. The Precambrian marbles of Bhedaghat formed first. Millions of years later, during the late Cretaceous, the Lameta Formation sediments with dinosaur remains were deposited. This was followed by the massive Deccan flood basalt eruptions. Finally, in the much more recent prehistoric era, humans created the famous rock art at Bhimbetka, utilizing the pre-existing geological landscape for shelter and expression.

81. (B) P-4, Q-1, R-3, S-2
Significant geoheritage and fossil sites are spread across various districts. Ghughwa is in Dindori. Bhimbetka is in Raisen. The Bagh Caves are located in Dhar. The Narmada Valley fossil area, specifically the Hathnora site, is associated with the Sehore and Hoshangabad districts. Matching these sites to their districts is essential for regional geological studies and the effective planning of geotourism and conservation efforts throughout Madhya Pradesh.

82. (C) Jabalpur and surrounding regions
While Madhya Pradesh is not the primary producer of iron ore in India, significant deposits are found in the Jabalpur district and adjacent areas. These ores are often associated with the Bijawar and Gwalior groups of rocks. Although smaller in scale compared to states like Odisha or Chhattisgarh, these local iron ore resources have historically supported regional smelting activities and remain a part of the state's diverse mineral portfolio.

83. (B) A location with geological elements of scientific or cultural value.
A Geoheritage Site is specifically defined as a location that contains geological features with significant scientific, educational, cultural, or aesthetic importance. These sites serve as windows into the Earth's past, illustrating key geological processes, fossil records, or unique landforms. They are valued not for industrial extraction, but for their role in understanding geological history and promoting environmental awareness, requiring careful conservation and sustainable management within the regional landscape.

18. (A) Paleolithic, Mesolithic, and later periods
The rock art at Bhimbetka spans a vast chronological range, with some paintings dating back to the Upper Paleolithic and Mesolithic periods. The art continues through the Chalcolithic, Iron Age, and into the medieval era. This long sequence of artistic expression provides an unparalleled record of cultural evolution, changing subsistence patterns, and human-environment interactions within the sandstone shelters of central India.

19. (C) A is true but R is false.
The Gondwana formations in Madhya Pradesh are economically significant because they contain the state's major coal reserves. However, while they host a substantial portion of India's coal, they do not account for over ninety percent of the national total when considering other states like Jharkhand and Chhattisgarh. Nevertheless, these formations are vital for the regional energy sector and industrial development.

20. (A) 3, 2, 4, 1
The geological history of Madhya Pradesh begins with the Archaean Basement Complex, followed by the Proterozoic Vindhyan Supergroup. Later, the Permo-Carboniferous to Mesozoic Gondwana Supergroup was deposited in structural basins. The sequence concludes with the Cretaceous to Paleogene Deccan Traps volcanic eruptions. This chronological order represents the transition from ancient crystalline foundations to relatively younger volcanic cover across the state.

21. (C) Gondwana Supergroup
Major coal mining operations by Western Coalfields Limited and Northern Coalfields Limited in Madhya Pradesh target the Gondwana Supergroup. These sedimentary rocks contain extensive coal seams formed from ancient plant matter in continental basins. The distribution of these coalfields in regions like Singrauli and the Pench-Kanhan valley is directly linked to the occurrence of these specific Permo-Carboniferous to Mesozoic sequences.

22. (C) Statement I is incorrect, but Statement II is correct.
Geotourism in Madhya Pradesh is designed to promote the appreciation of geological sites while emphasizing their conservation. The development of Geoparks is a strategic prospect to enhance this sector, providing a framework for protecting geodiversity and educating the public. Unlike Statement I suggests, conservation is a core pillar of geotourism, ensuring that unique geological features remain intact for future generations.

23. (D) 1, 2 and 3
The Ghughwa Fossil Park is located in the Dindori district and is renowned for its well-preserved paleobotanical remains. The site contains petrified tree trunks and plant specimens dating back to the late Cretaceous period. These fossils provide critical evidence regarding the flora that existed in central India just before the massive volcanic eruptions of the Deccan Traps shaped the regional landscape.

24. (A) A down-dropped block of land between two normal faults.
A graben is a tectonic feature characterized by a block of the Earth's crust that has dropped down between two parallel normal faults. The Narmada and Tapti rivers flow through such structures, which were formed by extensional forces within the Indian plate. These rift valleys are significant for understanding the structural geology and drainage patterns of central India, especially in Madhya Pradesh.

25. (C) Tawa Reservoir
While the Tawa Reservoir is a significant man-made waterbody and irrigation project, it is not a designated Ramsar site. In contrast, the Bhoj Wetland, Sakhya Sagar, and Yashwant Sagar have received this international status due to their ecological importance as waterfowl habitats. Ramsar sites are recognized under an international treaty to promote the conservation and wise use of wetlands of global significance.

26. (C) Precambrian Marbles
The famous marble rocks at Bhedaghat are part of the Sausar Group, which dates back to the Precambrian era. These rocks underwent high-grade metamorphism, transforming original limestone into the stunning white and colored marbles seen today. The Narmada River has carved a deep gorge through this resistant formation, creating a unique geotourism site that

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human evolution and migration. These fossils, found within fluvial sediments, help researchers reconstruct the prehistoric environments and movement patterns of early humans across the central Indian landscape.

44. (D) Deep-sea diving to explore coral reefs.
Geotourism in Madhya Pradesh focuses on its diverse inland geological features, such as the fossil parks at Ghughwa, the marble gorge at Bhedaghat, and the prehistoric rock art at Bhimbetka. Since the state is landlocked and lacks a coastline, activities like deep-sea diving to explore coral reefs are not possible. Instead, the state offers unique opportunities to explore ancient sedimentary basins, volcanic plateaus, and tectonic rift valleys.

45. (A) Both A and R are true and R is the correct explanation of A.
The Bundelkhand Gneissic Complex consists of ancient granitic and metamorphic rocks that form the core of northern Madhya Pradesh. These rocks date back to the Archaean Eon, making them over two and a half billion years old. As part of a stable basement craton, they represent the oldest geological foundations of the state, upon which all subsequent sedimentary and volcanic units were eventually deposited.

46. (C) Carbonate of calcium and magnesium.
Dolomite is a sedimentary rock-forming mineral with the chemical composition of calcium magnesium carbonate. It is widely found in the various stratigraphic units of Madhya Pradesh, including the Vindhyan and Sausar groups. Industrially, dolomite is highly valued for its use in the iron and steel industry as a flux, as well as in the production of glass, ceramics, and fertilizers across the state.

47. (C) Statement I is incorrect, but Statement II is correct.
While Madhya Pradesh has significant water resources, not all natural waterbodies are perennial. Many rivers and lakes depend entirely on monsoon rainfall and experience significant reductions in volume or dry up completely during the harsh summer months. This seasonal variation is a critical factor in the state's hydrogeology, necessitating careful water management and the use of dams and reservoirs to ensure year-round availability for human needs.

48. (B) Combination of marble rock gorges and dinosaur fossil sites.
The justification for a Geopark in the Jabalpur region lies in its unique assemblage of geological and paleontological heritage. Bhedaghat offers world-class exposures of Precambrian marble carved into a stunning gorge by the Narmada River. Nearby, the Lameta Formation provides globally significant dinosaur fossil sites. This combination of spectacular landforms and rare fossils makes the area a prime candidate for international recognition and conservation through the Geopark model.

49. (A) 1 and 2 only
The Narmada-Son lineament is a fundamental crustal feature that has been active since the Proterozoic era. Parallel to this, the Tapti River flows through its own graben structure, formed by similar tectonic forces. While the region is part of the stable Indian shield, it is not entirely inactive; periodic seismicity has been recorded along these major fault zones, refuting the idea of total tectonic inactivity in Madhya Pradesh.

50. (A) The transition from hunting-gathering to agriculture and settled life.
The prehistoric rock art at Bhimbetka provides a visual record of human cultural development over thousands of years. Early paintings depict hunting and gathering scenes, while later layers show the domestication of animals, communal dancing, and agricultural activities. This artistic sequence offers invaluable archaeological evidence regarding the evolution of social structures and the transition toward settled lifestyles among early human populations in the central Indian heartland.

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51. (C) Deccan Traps
The Deccan Traps represent a massive volcanic province characterized by multiple layers of basaltic lava flows. In Madhya Pradesh, these traps cover a significant portion of the western Malwa plateau. Formed by fissure eruptions during the late Cretaceous and early Paleogene, the resulting basaltic landscape has a profound influence on regional topography, the

35. (A) Lameta Formation
The discovery of dinosaur fossils, including bones, nests, and eggs, in the Narmada Valley is primarily associated with the Lameta Formation. This sedimentary sequence, dating to the late Cretaceous, was deposited in fluvial and lacustrine environments just before the Deccan Trap eruptions. Sites near Dhar and Jabalpur have yielded significant paleontological evidence, making this formation world-renowned for studying Mesozoic terrestrial life.

36. (A) 1 and 2 only
The Vindhyan Supergroup is largely unfossiliferous, with life during its deposition limited to microfossils and stromatolites. It is a major source of essential building materials like high-quality sandstone and limestone used across India. However, it is geologically much older than the Gondwana Supergroup, which was deposited during the Permo-Carboniferous to Mesozoic eras, following the long period of Vindhyan sedimentation and uplift.

37. (D) Manganese - Sidhi
In Madhya Pradesh, manganese production is primarily centered in the Balaghat and Chhindwara districts, with the Bharveli mine being a major source. Sidhi and Singrauli are instead renowned for their massive coal deposits within the Gondwana formations. The other pairs correctly link Panna with diamonds, Balaghat with copper, and Singrauli with coal, reflecting the state's specific regional distribution of major mineral resources.

38. (A) Conserve the wetland and promote its wise use.
The primary goal of the Ramsar Convention is the conservation and sustainable utilization of wetlands. Declaring a site as a Ramsar Wetland encourages 'wise use,' which means maintaining the ecological character of the area through the implementation of ecosystem approaches. This designation helps protect biodiversity, especially for waterfowl, while ensuring the wetland continues to provide essential services to local human populations.

39. (C) Kolans
Bhojtal, a historic man-made lake in Bhopal, was created by Raja Bhoj through the construction of an earthen dam across the Kolans River. This eleventh-century engineering feat was designed to ensure a reliable water supply and manage the regional drainage. Today, it stands as a prominent Ramsar site, serving as a critical environmental and hydrogeological landmark that continues to support the city's water needs.

40. (A) 2, 3, 4, 1
Arranging these sites from north to south follows the geography of Madhya Pradesh. Gwalior Fort is in the northernmost part. Moving south, the Bhimbetka Rock Shelters are located near Raisen in the center. Further south and east lies Bhedaghat near Jabalpur. Finally, the Bagh Caves are situated in the Dhar district toward the southwest, completing the latitudinal sequence of these significant cultural and geological landmarks.

41. (B) Groundwater availability is found in weathered zones and hard rock fractures.
The crystalline groundwater province in Madhya Pradesh consists of ancient igneous and metamorphic rocks like granite and gneiss. These rocks lack primary porosity, meaning they do not store water within the rock itself. Instead, groundwater is stored and transmitted through the secondary porosity created by weathering and tectonic fracturing. This makes groundwater availability highly localized and dependent on the thickness of the weathered mantle.

42. (B) P-3, Q-1, R-4, S-2
Mineral-based industries in the region are strategically located near their raw material sources. Thermal power plants are concentrated in Singrauli due to massive coal deposits. Cement plants thrive in Satna because of abundant limestone. Alumina refineries are often linked to bauxite sources in the Korba region. Copper smelting is centered near Malanjkhand in Balaghat, which hosts India's largest open-cast copper mine.

43. (C) Early human evolution and migration in the Indian subcontinent.
The discovery of the Narmada Man (Homo erectus) skull cap at Hathnora is a landmark find in paleoanthropology. It provides rare evidence of middle Pleistocene hominid presence in South Asia, bridging gaps in our understanding of early

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showcases the intersection of ancient geology and fluvial erosion.

27. (C) Vindhyan Supergroup
A sequence containing sandstone, shale, and limestone with stromatolite fossils is characteristic of the Vindhyan Supergroup. Stromatolites are sedimentary structures formed by the activity of ancient cyanobacteria, which are common in the Proterozoic rocks of this unit. The Presence of these features in central Madhya Pradesh indicates a shallow marine environment during the deposition of these extensive and historically stable sedimentary layers.

28. (A) Ancient traditions of harvesting rainwater in water-scarous areas.
The numerous ancient man-made waterbodies, known as talabs, in the Bundelkhand region reflect a historical adaptation to the local semi-arid climate and hard-rock geology. These structures were designed to harvest and store rainwater, providing a reliable source for irrigation and domestic use in a region where natural perennial water is limited. They represent a significant aspect of the state's cultural and hydrogeological heritage.

29. (B) P-4, Q-1, R-3, S-2
Madhya Pradesh's geoheritage sites are characterized by unique features. Bhimbetka is world-famous for prehistoric rock art. Bhedaghat features a stunning marble rocks gorge. The Bagh Caves are known for their rock-cut Buddhist architecture. Ghughwa serves as a vital site for petrified plant fossils. This variety highlights the state's rich intersection of geological processes and ancient human history, making it a prime destination for geotourism.

30. (B) Underlying lithology and geological structure.
The groundwater provinces of Madhya Pradesh are defined primarily by the physical properties of the underlying rocks and their structural arrangements. Factors such as porosity, permeability, fracturing, and weathering determine how water is stored and moves underground. While rainfall provides recharge, the actual availability and yield of groundwater depend on whether the province consists of porous sandstones, fractured basalts, or crystalline basement rocks.

31. (D) A major west-east trending zone of structural faulting and weakness.
The Narmada-Son Lineament is a fundamental tectonic feature consisting of a broad zone of faults and shear zones trending roughly east-west across central India. It represents a long-standing zone of weakness in the crust that has influenced sedimentation, volcanic activity, and modern seismicity. This lineament effectively divides the Indian subcontinent into two major geological blocks, shaping the region's diverse stratigraphic and structural evolution.

32. (A) Both A and R are true and R is the correct explanation of A.
The Deccan Traps are classified as flood basalts because they were formed by massive, highly fluid lava eruptions from fissures rather than single volcanoes. These flows covered vast areas, including much of western Madhya Pradesh, creating a thick volcanic plateau. This igneous activity occurred during the late Cretaceous to early Paleogene, significantly impacting the region's topography, soil development, and hydrogeological characteristics.

33. (C) Cement and lime production
Katni is famously known as the 'Limestone City' because it sits on extensive deposits of high-quality limestone within the Vindhyan Supergroup. This abundance of raw material has led to a heavy concentration of cement and lime-producing industries in the district. The local geology directly supports these mineral-based economic activities, making Katni a critical hub for the construction materials sector in central India.

34. (D) Madhav National Park
Sakhya Sagar is a significant wetland located within the boundaries of Madhav National Park in Shivpuri. This man-made reservoir, created on the Manier River, was recently designated as a Ramsar site. It serves as a vital ecosystem supporting diverse flora and fauna, including mugger crocodiles and numerous bird species, highlighting the integration of historical water management and modern biodiversity conservation in the state.

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formation of black cotton soils, and the specific hydrogeological patterns of the area.

52. (B) Manganese
The Bharveli mine in the Balaghat district is renowned as Asia's largest and deepest underground manganese mine. It produces high-quality manganese ore, which is an essential raw material for the production of steel and various alloys. The mine's immense reserves and consistent output make it a cornerstone of the mineral industry in Madhya Pradesh and a significant contributor to India's national mineral exports.

53. (B) Indore
Yashwant Sagar is a significant wetland and reservoir located near the city of Indore. It was created by constructing a dam across the Gambhir River to provide water for the city. Recently designated as a Ramsar site, it serves as an important habitat for diverse bird species and plays a crucial role in local biodiversity conservation. Its proximity to Indore makes it a vital environmental asset for the urban region.

54. (D) Modern agricultural practices in a region.
Geoheritage refers to the variety of non-living nature, including fossils, landforms, and rock formations that possess scientific, cultural, or aesthetic value. It focuses on features that illustrate Earth's history and geological processes. While modern agricultural practices are important for human survival and cultural landscape development, they do not fall under the definition of geoheritage, which is strictly concerned with the geological and geomorphological aspects of the natural world.

55. (B) P-4, Q-3, R-1, S-2
The geological features of Madhya Pradesh have distinct origins. The Narmada Rift is an east-west trending graben. The Deccan Traps are a Cretaceous-Paleogene flood basalt province. The Bundelkhand Craton is an ancient Archaean granitic nucleus, while the Vindhyan Basin is a major Proterozoic sedimentary sequence. This variety showcases the complex tectonic history and diverse rock types that define the central Indian landscape across billions of years of Earth history.

56. (C) The presence of limestone has led to a thriving cement industry.
Madhya Pradesh's mineral wealth directly supports various industries. The extensive limestone deposits in the Vindhyan Supergroup, particularly in districts like Satna, Katni, and Rewa, have fostered a thriving cement manufacturing sector. While the state produces many minerals, it does not process all of them internally. Additionally, it possesses significant thermal power plants fueled by its large coal reserves, and mining remains the primary economic driver of the diamond sector.

57. (B) Buddhism, Vakataka-Gupta period
The Bagh Caves are a series of nine rock-cut monuments that served as Buddhist monasteries and dwellings. Their creation is attributed to the Vakataka and Gupta periods, roughly between the fourth and sixth centuries AD. The caves are famous for their intricate architecture and murals, which reflect the artistic and religious traditions of that era. They represent a significant historical and cultural landmark carved into the regional sedimentary rock formations.

58. (A) Both A and R are true and R is the correct explanation of A.
The Malwa plateau, covered by the Deccan Traps, faces severe groundwater depletion. Basaltic rock naturally has low primary porosity, meaning water can only be stored in fractures or weathered zones. Without these features, rainwater runs off rather than infiltrating the ground. High agricultural demand and limited natural storage capacity create a precarious hydrogeological situation, leading to the rapid lowering of water tables across this important agricultural region of Madhya Pradesh.

59. (A) The presence of both hominid fossils and a continuous record of stone tool industries.
The Narmada Valley is a premier geoarchaeological site due to its unique combination of paleontological and archaeological finds. It has yielded rare hominid fossils, such as the Narmada Man, alongside a deep, stratified record of stone tools spanning from the Lower Paleolithic to the Mesolithic. This evidence allows researchers to trace human evolution, technological progress, and environmental adaptations over hundreds of

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thousands of years within a single geographical region.

60. (B) 1, 4, 3, 2
The chronological designation of Ramsar sites in Madhya Pradesh began with the Bhoj Wetland in 2002. There was a long gap before the next sites were added. In 2022, a significant expansion occurred with the designation of Sakhya Sagar in July, followed by Sirpur Lake and Yashwant Sagar in August. This sequence reflects the increasing momentum in recognizing and protecting the state's diverse wetlands under the international framework of the Ramsar Convention.

61. (A) Alternating layers of sandstone, shale, and coal seams.
The Gondwana Supergroup in Madhya Pradesh is a thick sedimentary sequence primarily composed of alternating layers of sandstone and shale. Crucially, it hosts significant coal seams, which were formed from ancient plant matter in continental basins. These rocks were deposited from the late Paleozoic to the Mesozoic eras. Their distinct lithology and mineral content make them the primary source of the state's thermal energy and essential for various industrial applications.

62. (C) 1 and 3 only
The Jabalpur-Bhedaghat area is an excellent candidate for a Geopark due to its stunning marble rocks and significant fossil records. Geoparks are not exclusive to research; they actively encourage tourism and local community involvement to foster sustainable economic growth. The overarching goal is to conserve geological heritage while providing educational opportunities. Therefore, the focus is on a holistic approach that integrates science with community development and environmental protection.

63. (C) Porous sandstones
In the Gondwana groundwater province of Madhya Pradesh, the primary aquifers are the porous sandstones within the sedimentary sequence. These sandstones possess significant primary porosity, allowing them to store and transmit large volumes of groundwater. While shale layers within the same sequence may act as barriers, the sandstones provide reliable water sources for agriculture and domestic use in the eastern and central parts of the state where these formations are prevalent.

64. (C) Jayant
The Jayant mine is one of the largest open-cast coal mines in India, located in the Singrauli district. It is operated by Northern Coalfields Limited and exploits the massive coal seams found in the Gondwana formations. This mine is a critical supplier for various thermal power plants across the country. In contrast, Malanjkhand is for copper, Bharveli for manganese, and Majhgawan is the famous diamond mine in Panna.

65. (C) Ajanta Caves
The art found in the Bagh Caves, particularly the murals and frescoes, shows a strong stylistic resemblance to the world-renowned Ajanta Caves in Maharashtra. Both sites represent the pinnacle of Buddhist art during the Vakataka and Gupta periods. The use of tempera techniques and the depiction of religious and secular themes at Bagh demonstrate the widespread influence of the Ajanta style across the regional artistic landscape of ancient India.

66. (A) Both Statement I and Statement II are correct.
The Bhoj Wetland in Bhopal is composed of two interconnected waterbodies: the Upper Lake and the Lower Lake. Designated in 2002, it was the first site in Madhya Pradesh to be recognized under the Ramsar Convention. This wetland serves as a critical ecosystem for urban biodiversity and a primary source of water for the city, highlighting the importance of conserving both man-made and natural water resources in the state.

67. (C) Fluvial erosion and headward erosion in a tectonically uplifted area
The dramatic ravines and deep gorges of the Chambal region are the result of intense fluvial erosion within a tectonically active and uplifted landscape. High rates of headward erosion by the Chambal River and its tributaries have carved through soft alluvial deposits and resistant rock alike. This process has created a unique but challenging 'badland topography,' demonstrating how active geological forces and river dynamics can rapidly reshape large areas of the state.

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68. (A) P-4, Q-1, R-3, S-2
Madhya Pradesh's mineral wealth is geographically concentrated based on its underlying geology. Balaghat is synonymous with high-quality manganese ore. Panna is uniquely famous for its diamond mines. Katni is known as the 'Limestone City' due to its extensive sedimentary deposits. Singrauli hosts some of India's largest coal mines in the Gondwana basins. This distribution highlights how different stratigraphic units provide specific resources across various districts of the state.

69. (B) It preserves petrified tree trunks and plant fossils from 65 million years ago.
The Mandla Plant Fossils National Park at Ghughwa is globally significant for its extraordinary collection of petrified flora. The site preserves tree trunks, seeds, and leaves that have been converted into stone over sixty-five million years. These fossils date to the late Cretaceous period, providing a rare and detailed snapshot of the terrestrial vegetation that existed in central India just before the onset of the massive Deccan Trap volcanic eruptions.

70. (C) The plunge pool below Dhuandhar falls
While Gandhi Sagar, Tawa, and Bhojtal are all man-made reservoirs or dammed waterbodies, the plunge pool below the Dhuandhar falls is a natural feature. It was formed by the sheer force of the Narmada River falling over the resistant marble rocks at Bhedaghat. This pool represents a dynamic interaction between fluvial processes and regional geology, standing in contrast to the numerous human-engineered lakes and reservoirs found across the state's landscape.

71. (A) Both A and R are true and R is the correct explanation of A.
Vindhyan sandstones are highly valued as building and ornamental stones because of their excellent physical properties. The rocks occur in near-horizontal beds, making them easy to quarry in large, flat slabs. Furthermore, they are available in a variety of attractive colors and textures, ranging from fine-grained red to buff shades. Their durability and aesthetic appeal have made them a preferred material for historic monuments and modern architecture alike.

72. (B) Reconstruct the geological history, climate, and life of past eras.
Studying the various stratigraphic units of Madhya Pradesh allows scientists to piece together the state's long and complex geological narrative. Each rock layer serves as a record of ancient environments, from shallow marine basins to volcanic plateaus. By analyzing these sequences, geologists can reconstruct past climates, the evolution of life through fossils, and the tectonic movements that shaped the Indian subcontinent, providing a comprehensive understanding beyond mere mineral extraction.

73. (B) Follow the gradient of pre-existing tectonic troughs (rift valleys).
The Narmada and Tapti rivers flow westward because their paths are dictated by major tectonic rift valleys or grabens. Unlike most peninsular rivers that follow the general eastward tilt of the Indian plate, these two rivers are constrained within deep-seated structural troughs trending east-west. This tectonic control forces them to flow toward the Arabian Sea, making them unique features in the overall drainage network of the central Indian subcontinent.

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74. (C) Aluminium production
Bauxite is the primary ore for aluminum, and Madhya Pradesh possesses significant reserves of this mineral, especially in the Amarkantak and Rewa regions. These deposits directly support the aluminum industry, providing the raw material for smelting and refining processes. Industries like HINDALCO and BALCO have historically relied on bauxite extracted from these high-altitude plateaus, making the mineral a vital component of the state's industrial and economic framework.

75. (C) 1 and 3 only
Bhimbetka provides evidence of continuous human settlement for thousands of years, making it a globally unique archaeological site. The Narmada Valley is equally significant for its diverse fossil record, including both prehistoric mammals and early hominids like the Narmada Man. However, the Bagh Caves are man-made rock-cut structures, not natural limestone caverns. Together, these sites represent the deep and varied human and natural history preserved within Madhya Pradesh's geological landscape.

9. (C) Intricate rock-cut architecture and ancient murals
The Bagh Caves in the Dhar district are a group of nine rock-cut monuments renowned for their ancient Buddhist architecture. These caves were carved into the sandstone cliffs and are famous for their elaborate murals and tempera paintings. Reflecting the artistic excellence of the Gupta period, the site represents a significant intersection of geological materials and historical human creative expression.

10. (A) 1 and 2 only
Madhya Pradesh contains vast coal reserves primarily located within the Gondwana formations of the eastern regions. Additionally, the Panna district is historically and geologically famous for its diamond mines, which are the only active commercial sources in India. While bauxite exists, it is largely concentrated in the eastern and central plateaus rather than the western districts of the state.

11. (D) Sirpur Lake
Sirpur Lake, located in Indore, was officially designated as a Ramsar Site in 2022, reflecting its international ecological importance. This wetland serves as a crucial habitat for numerous migratory and resident bird species. Its recognition under the Ramsar Convention highlights the state's commitment to conserving urban wetlands and promoting the wise use of these vital biodiversity hubs for environmental sustainability.

12. (B) The entire state is composed of geologically recent alluvial deposits.
Madhya Pradesh features a highly diverse geological landscape, ranging from ancient Archaean rocks to the expansive Deccan Traps. While alluvial deposits exist along major river valleys like the Narmada and Chambal, they do not cover the entire state. Significant portions are composed of the Proterozoic Vindhyan Supergroup and Mesozoic Gondwana formations, contradicting the idea of a purely alluvial composition.

13. (C) Vindhyan Supergroup
The Satna and Rewa regions are major centers for the cement industry due to the abundance of high-grade limestone. This limestone is sourced from the Vindhyan Supergroup, a prominent Proterozoic sedimentary sequence in northern Madhya Pradesh. The extensive and accessible nature of these limestone beds makes the region ideal for large-scale cement production, supporting infrastructure development across the Indian subcontinent.

14. (D) A natural rock formation with scientific or aesthetic value.
In the context of geodiversity, a Rock Monument refers to a natural geological feature that possesses significant scientific, educational, or aesthetic importance. Examples include unique landforms created by weathering, such as the Balancing Rock in Jabalpur. These monuments serve as key attractions for geotourism and provide valuable insights into the geological processes that have shaped the landscape over millions of years.

15. (A) Cenozoic
The Narmada Valley is globally recognized for its rich fossil record, particularly from the Cenozoic era. Significant discoveries include Pleistocene mammalian remains and early hominid fossils, such as the Narmada Man skull cap. These findings are crucial for understanding the evolution of fauna and early human migration in the Indian subcontinent within the context of the region's fluctuating ancient environments.

16. (A) P-4, Q-2, R-1, S-3
Mineral extraction in Madhya Pradesh is concentrated in specific geological zones. Singrauli is a major hub for coal mining within Gondwana formations. The Bharveli mine in Balaghat is famous for manganese, while Panna remains the sole source for diamonds. Bauxite is extensively mined on the Amarkantak Plateau. This distribution reflects the diverse stratigraphic units that host these valuable economic resources.

17. (B) Bhojtal (Upper Lake) in Bhopal
Bhojtal, formerly known as the Upper Lake, is a significant man-made waterbody in Bhopal created by Raja Bhoj in the eleventh century. Formed by constructing an earthen dam across the Kolans River, it represents an ancient feat of hydrogeological engineering. As a designated Ramsar site, it remains a primary source of drinking water and a vital ecological asset for the city.

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84. (A) Both A and R are true and R is the correct explanation of A.
The Lameta Formation is of immense paleontological importance because it represents the environment of India just before the Deccan Traps eruptions. As an infratrappean sequence, it lies directly beneath the basalt flows. It has yielded world-class fossils, including extensive dinosaur nesting sites and eggs, particularly in the Jabalpur and Dhar regions. These finds provide critical insights into the diversity and behavior of late Cretaceous terrestrial life in central India.

85. (C) Joints, fractures, and bedding planes of sandstones and limestones.
Groundwater in the Vindhyan provinces of Madhya Pradesh is primarily stored in the secondary porosity of sedimentary rocks. While sandstones and limestones may have some primary porosity, the movement and accumulation of water are largely controlled by structural features such as joints, fractures, and horizontal bedding planes. These features allow water to infiltrate and flow through the otherwise dense rock, forming aquifers that are critical for regional water supplies.

86. (D) Gold for electronics
Madhya Pradesh's industrial economy is built on its primary mineral resources. Limestone is the backbone of the cement industry. Coal is extensively used for thermal power generation. Bauxite is the essential raw material for aluminum production. However, gold is not a prominent mineral resource in the state. Consequently, the state does not have a major gold-based industrial sector, unlike the well-established industries based on limestone, coal, and bauxite deposits.

87. (C) Statement I is incorrect, but Statement II is correct.
The rock art at Bhimbetka is not the product of a single period or culture. Instead, it represents a remarkable chronological sequence where paintings from different eras are often superimposed on one another. This stratification shows stylistic changes and evolving subject matter, indicating that these shelters were occupied continuously for thousands of years. This long-term cultural evolution is what gives Bhimbetka its outstanding universal value as a UNESCO World Heritage site.

88. (A) 3 only
Ramsar sites in Madhya Pradesh, such as the Bhoj Wetland and Yashwant Sagar, are recognized primarily for their international importance as habitats for waterfowl. Many of these sites are actually man-made or modified by human activity, contradicting the idea that they must be pristine. Furthermore, designation does not halt all economic activity; instead, it promotes 'wise use,' encouraging sustainable practices that balance human needs with the ecological integrity of the wetland ecosystem.

89. (C) Diamond-bearing kimberlite pipe and associated geology
A Geopark in the Panna region would center on its world-unique diamond geology. The area features primary diamond-bearing kimberlite pipes and secondary conglomerate deposits. This geological setting is not found elsewhere in India on a commercial scale. A Geopark would highlight the volcanic processes that brought diamonds to the surface billions of years ago, integrating scientific education with the state's historical and economic narrative of diamond mining and exploration.

90. (C) Found below the Deccan Traps.
The term 'infratrappean' is used to describe the Lameta beds because they are stratigraphically positioned immediately beneath the Deccan Trap basalt flows. This location indicates that the Lameta sediments were deposited just prior to the massive volcanic activity. The contact between these two units is a significant geological boundary, representing the transition from a stable sedimentary environment to a period of intense and widespread flood basalt volcanism in central India.

91. (C) Singrauli Coalfield - Singrauli
The Singrauli Coalfield is a major coal-producing region located in the Singrauli district of Madhya Pradesh. It is part of the Gondwana basin and hosts some of India's thickest coal seams. This coalfield is essential for the numerous thermal power plants in the area. Other famous fields like Jharia and Raniganj are located in Jharkhand and West Bengal, respectively, making the Singrauli-Singrauli pair the correct regional match for Madhya Pradesh.

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these associations is vital for mapping the state's geological history and identifying areas for mineral exploration.

108. (C) Weathering, water seepage, and anthropogenic factors like vandalism.
The prehistoric paintings at Bhimbetka face multiple conservation challenges. Natural processes like the weathering of the sandstone surface and water seepage through the rock can degrade the ancient pigments. Furthermore, human activities, including vandalism and unregulated tourism, pose significant risks to the integrity of the art. Protecting this UNESCO World Heritage site requires careful management of both environmental factors and visitor interactions to preserve the paintings for future generations.

109. (D) Pench National Park
While Pench National Park is a renowned tiger reserve and protected forest area, it is not designated as a Ramsar site. In contrast, Sirpur Wetland, Sakhya Sagar, and the Bhoj Wetland have received international recognition under the Ramsar Convention due to their specific ecological importance as wetlands. These designations highlight the need to protect diverse waterbodies across the state that serve as critical habitats for migratory birds and other aquatic biodiversity.

110. (A) Both A and R are true and R is the correct explanation of A.
Geologists use stratigraphic maps as primary tools for mineral exploration because specific minerals are inherently tied to particular geological formations. For example, coal is almost exclusively found in Gondwana basins, while high-grade limestone is associated with the Vindhyan Supergroup. By identifying the distribution of these rock units, the state can systematically explore and manage its mineral wealth, ensuring that industrial development is guided by a scientific understanding of regional geology.

111. (A) To provide drinking and irrigation water for the city of Bhojpal
Raja Bhoj created the Upper Lake (Bhojtal) in the eleventh century primarily to serve as a reliable water reservoir for his city, Bhojpal. By damming the Kolans River, he successfully managed the regional water resources for both domestic use and agriculture. This historic project remains a remarkable example of ancient hydrogeological engineering, continuing to provide a significant portion of the modern city of Bhopal's water supply nearly a millennium later.

112. (B) Igneous intrusive activity.
Dykes and sills are igneous bodies formed when molten magma is injected into pre-existing rock layers. A dyke cuts across the host rock's bedding, while a sill parallel it. The presence of these features across various geological formations in Madhya Pradesh provides evidence of ancient periods of volcanic and intrusive activity. They are critical for understanding the thermal history and tectonic stresses that have affected the regional crust over geological time.

113. (A) 'Wise use' of the wetland's resources.
The Ramsar Convention promotes the 'wise use' principle, which encourages the conservation and sustainable utilization of wetlands. This approach recognizes that wetlands are essential for both biodiversity and human well-being. By adopting wise use practices, governments and communities can manage these ecosystems to provide water, food, and recreation without damaging their ecological integrity. This international framework helps ensure that Madhya Pradesh's designated wetlands continue to function as healthy and productive environments.

114. (B) 2 and 3 only
The Ghughwa Fossil Park is world-renowned for its petrified plant fossils, including tree trunks and seeds, rather than dinosaur eggs. On the other hand, the Lameta Formation near Jabalpur and Dhar is famous for its wealth of dinosaur fossils, including remains and egg nests. Together, these sites highlight the diverse late Cretaceous ecosystems of Madhya Pradesh, providing a comprehensive view of both the terrestrial flora and fauna that existed before the Deccan Traps.

115. (A) The Narmada river cutting through a belt of Precambrian marble.
The spectacular gorge at Bhedaghat was formed by the Narmada River eroding through a thick belt of resistant Precambrian marble. Over

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to the state's hydro-archaeological heritage, showcasing how historical societies adapted to their geological and climatic environments to ensure regional water security.

100. (A) 4, 1, 3, 2
The geological timeline of Madhya Pradesh begins with the formation of the Archaean Bundelkhand Craton. This was followed by the deposition of Proterozoic Vindhyan sediments. Subsequently, the Gondwana sequence started during the Permo-Carboniferous period. Finally, the Deccan flood basalt eruptions commenced during the Cretaceous. This sequence reflects the progressive building of the regional crust through distinct tectonic and sedimentary phases across billions of years of history.

101. (B) 2 and 3 only
Madhya Pradesh is the sole producer of diamonds in India, primarily through the mines in the Panna district. Additionally, the state is a national leader in the production of manganese and copper, with major mines in the Balaghat region. However, the state does not hold a monopoly on all minerals; for example, iron ore and coal are produced in significant quantities by several other Indian states, reflecting a diverse national mineral distribution.

102. (B) Divides the Indian subcontinent into two distinct geological blocks.
The Narmada-Son Lineament is a fundamental tectonic boundary that stretches across central India. Geologically, it separates the northern part of the subcontinent from the southern peninsular block. This ancient zone of weakness has influenced the region's structural evolution, sedimentation patterns, and volcanic history. Its role as a major crustal divider makes it one of the most significant features for geologists studying the assembly and tectonic dynamics of the Indian plate.

103. (B) An aquitard or aquifuge
Hard, unweathered granite is characterized by extremely low porosity and permeability. In its massive state, it does not allow for the storage or movement of water, thus acting as an aquitard or aquifuge. In the Bundelkhand Gneissic Complex, groundwater is only available where the rock has been significantly weathered or fractured. Consequently, the pristine, unweathered basement rock serves as a barrier rather than a productive source for groundwater extraction.

104. (C) Baghani
The Bagh Caves are situated on the banks of the Baghani River in the Dhar district. These rock-cut Buddhist monasteries were carved into the sandstone cliffs overlooking the river. The proximity to the water source was essential for the monks living in these retreats. This setting demonstrates a classic integration of geological features, historical architecture, and natural drainage systems, making the site an important landmark of Madhya Pradesh's geoarchaeological heritage.

105. (C) Statement I is incorrect, but Statement II is correct.
The Ghughwa Fossil Park is uniquely famous for its paleobotanical remains rather than marine fossils. The site preserves petrified trunks, leaves, and seeds of various terrestrial plants, including palms and early flowering plants from the late Cretaceous. These fossils provide a detailed record of the terrestrial ecosystems that flourished in central India just before the Deccan Traps eruptions, offering a contrast to the marine fossils found in other parts of the country.

106. (C) Amarkantak-Rewa belt
The HINDALCO aluminium plant relies heavily on bauxite supplied from the high-altitude plateaus of the Amarkantak-Rewa belt. This region contains some of the state's most extensive and high-quality bauxite deposits, formed by the intense weathering of parent rocks. The proximity and quality of these resources in eastern Madhya Pradesh have historically made the state a critical supplier for the national aluminum industry, driving regional mining and economic development.

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107. (A) P-3, Q-4, R-1, S-2
Each stratigraphic unit in Madhya Pradesh is characterized by specific rocks and resources. The Deccan Traps consist of basaltic flows. The Gondwana Supergroup is famous for coal and sandstone. The Vindhyan Supergroup is a major source of limestone and ornamental sandstone. The ancient Archaean basement is composed of crystalline gneiss and granite. Understanding

92. (B) Groundwater movement is controlled by a dual system of weathered/vesicular zones and deeper fractures.
Hydrogeology in the Deccan Traps is complex due to the varying nature of basaltic lava flows. Some layers are dense and impermeable, while others are vesicular or highly weathered, allowing for water storage. Additionally, deeper tectonic fractures provide pathways for groundwater movement. This dual system means that water availability can vary significantly over short distances, requiring detailed geological investigations to successfully locate and manage groundwater resources in the Malwa region.

93. (A) They represent human-environment interactions within specific rock shelters.
Bhimbetka is considered a geoarchaeological site because it showcases how prehistoric humans utilized the natural geological landscape. The sandstone shelters provided protection and a durable surface for artistic expression. The paintings themselves reflect the people's interaction with the local flora, fauna, and geography. Studying these sites requires a multi-disciplinary approach that combines archaeological evidence of human activity with a geological understanding of the shelters and the materials used for painting.

94. (A) P-3, Q-1, R-4, S-2
Madhya Pradesh's prominent wetlands and ancient waterbodies are located across various cities. Bhojtal is the iconic lake of Bhopal. Sakhya Sagar is situated in Shivpuri within Madhav National Park. Both Sirpur Lake and Yashwant Sagar are located near Indore. Correctly identifying these locations is vital for environmental management and the promotion of the state's diverse hydro-heritage and its recognized Ramsar sites for biodiversity conservation.

95. (D) Siwalik Supergroup
The Siwalik Supergroup is a geological unit found in the Himalayan foothills and is not present in Madhya Pradesh. In contrast, the state features a wide range of other major units, including the ancient Archaean Complex, the Proterozoic Vindhyan Supergroup, and the Mesozoic Gondwana Supergroup. The absence of the Siwaliks highlights the state's position on the stable Indian peninsula, distinct from the younger tectonic regions of the northern mountain ranges.

96. (A) Coal-based power generation and cement
The Baghelkhand region in eastern Madhya Pradesh possesses vast reserves of coal and limestone. Prioritizing coal-based thermal power plants and cement manufacturing is a logical strategy for regional development. These industries can directly utilize the local Gondwana coal and Vindhyan limestone, creating economic value and infrastructure. This approach leverages the region's specific geological wealth to drive industrial growth and energy security for the state and the country.

97. (A) Both A and R are true and R is the correct explanation of A.
The Narmada Valley is a seismically active zone because it follows a deep-seated structural fault system known as the Narmada-Son Lineament. This zone represents a major line of weakness in the Indian crust. Periodic reactivation of these faults occurs due to the stresses generated by the northward movement of the Indian plate. These intra-plate stresses can trigger earthquakes, making the valley a region of significant concern for seismic monitoring and disaster management.

98. (B) Unique landforms created by natural processes of weathering and erosion.
Rock Monuments in Madhya Pradesh, such as the famous Balancing Rock in Jabalpur, are natural geological features. They were formed over long periods through the differential weathering and erosion of rock outcrops, typically granite or sandstone. These processes leave behind unusual shapes that seem precarious or artistically designed. These landforms are significant geoheritage sites, attracting tourists and providing educators with clear examples of how environmental forces shape the Earth's surface.

99. (A) Mun Sagar tank, Dhar
Mun Sagar is a historic man-made tank located in the Dhar district, representing an ancient tradition of water management in Madhya Pradesh. Unlike natural features like the Dhuandhar falls or river sources, this tank was intentionally engineered by past rulers to harvest and store water. Such structures are integral

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thousands of years, the river's force has carved deep into the metamorphic rock, creating high cliffs and the iconic Dhuandhar falls. This site is a classic example of fluvial geomorphology, where a major river's dynamic energy interacts with the regional geology to produce a landscape of immense scientific and aesthetic value.

116. (D) Panna
Panna is uniquely famous for its diamond mines and is not a significant coal-bearing district. In contrast, Singrauli, Shahdol, and Umaria are key regions for coal mining in Madhya Pradesh, as they host extensive Gondwana sedimentary basins. Coal extraction in these districts fuels major thermal power plants and supports the state's energy needs. The distinction between these mineral provinces reflects the underlying geological diversity that defines the state's economic landscape.

117. (B) Aquifer systems are universally interconnected throughout all rock formations.
Hydrogeology in Madhya Pradesh is highly varied, and aquifers are not universally interconnected. Instead, water storage is fragmented by different rock types, such as fractured basalts, porous sandstones, and dense granites. Groundwater movement is often restricted by impermeable layers, creating localized and distinct aquifer systems. This lack of uniformity makes groundwater management challenging and necessitates site-specific studies to ensure sustainable use and effective recharge across the state's diverse geological provinces.

118. (A) On a prepared surface of mud-plaster (tempera)
The paintings in the Bagh Caves were executed using the tempera technique. This involved applying a layer of mud-plaster or lime over the sandstone walls to create a smooth, prepared surface for the artists. This method allowed for intricate details and vibrant colors in the depictions of religious and secular scenes. The preservation of these murals is highly dependent on the stability of this plaster layer within the challenging cave environment.

119. (C) Conserving dinosaur fossil sites and marble rock gorges.
A proposed 'Lameta Geopark' would focus on the unique geological and paleontological features of the Jabalpur region. This includes the late Cretaceous Lameta Formation, famous for its dinosaur fossils, and the stunning Precambrian marble gorge at Bhedaghat. By protecting these diverse features under a Geopark framework, the state can promote scientific research and geotourism while ensuring that these irreplaceable aspects of its natural heritage are preserved for the future.

120. (C) P-4, Q-1, R-3, S-2
Mineral-based industries rely on specific geological raw materials. Cement plants require limestone from the Vindhyan Supergroup. Thermal power plants use coal from Gondwana formations. Copper smelters process chalcopyrite ore, such as that from the Malanjkhand mine. Diamond mines extract gemstones from kimberlite or lamproite rocks. This mapping shows how the state's diverse stratigraphic units provide the essential inputs for a wide range of industrial and economic activities across central India.

121. (B) The slope of the Deccan Traps.
The Son River originates near the Amarkantak plateau and flows eastward, following the general north-northeastern slope of the landscape. This drainage direction is influenced by the regional topography, which was shaped by the extensive Deccan Trap lava flows and the subsequent uplift of the plateau. While the Narmada-Son Lineament provides a structural corridor, the actual flow direction of the Son is a response to the tilted regional gradient of the peninsular shield.

122. (C) There is a superposition of paintings from different eras and styles.
A key characteristic of the rock art at Bhimbetka is the superposition of paintings. Artists from different prehistoric and historic periods frequently used the same rock surfaces, layering new scenes over older ones. This creates a complex visual record that allows archaeologists to trace the evolution of styles, subject matter, and cultural practices over thousands of years. It highlights the long-standing significance of these

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shelters as centers of human social and artistic activity.

123. (A) Both A and R are true and R is the correct explanation of A.
The Gondwana Supergroup is absent in northern districts like Gwalior because the region is dominated by much older rock units. The Archaean Bundelkhand Gneiss and the Proterozoic Vindhyan Supergroup form the bedrock in these areas. Since the Gondwana basins were formed by specific rifting events in other parts of the subcontinent, they were never deposited on the stable northern platform, resulting in a distinct geological character for the Gwalior and Bundelkhand regions.

124. (D) Deccan Traps
The term 'Malwa Traps' is often used interchangeably with the Deccan Traps to describe the extensive basaltic plateau of western Madhya Pradesh. These volcanic rocks were formed by massive flood basalt eruptions during the late Cretaceous and early Paleogene. They define the topography, soil types, and hydrogeology of the Malwa region. The use of the term 'Traps' refers to the step-like appearance of the landscape created by successive horizontal lava flows.

125. (A) Human interaction and management of water resources
The combination of natural waterbodies and numerous ancient man-made tanks in Madhya Pradesh highlights a long history of sophisticated water management. For centuries, regional societies have engineered the landscape to capture rainfall and recharge groundwater, adapting to the seasonal monsoon climate. This hydro-heritage reflects a deep understanding of the local geology and the necessity of managing water for domestic use, agriculture, and urban survival across different historical periods.

126. (B) High-grade iron ore
While Madhya Pradesh possesses abundant coal, limestone, and water, its reserves of high-grade iron ore are relatively limited compared to states like Odisha or Chhattisgarh. This scarcity is a major constraint for establishing large-scale integrated steel plants within the state. Most iron ore used in existing regional industries must be transported from neighboring areas, highlighting how specific geological constraints can shape the industrial and economic landscape of a particular region.

127. (B) 1 and 2 only
Madhya Pradesh's geodiversity is remarkable, spanning billions of years from ancient Archaean granites to modern river alluvium. It also includes world-class tectonic features like the Narmada Rift Valley. This diversity is not uniform across the state; instead, different regions exhibit distinct geological characters, such as the volcanic Malwa plateau, the sedimentary Vindhyan ranges, and the coal-bearing Gondwana basins. This regional variation is the foundation of the state's diverse mineral wealth and landscapes.

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128. (B) Increased recognition of the ecological importance of these man-made and natural wetlands.
The recent designation of several sites as Ramsar wetlands in 2022 reflects a growing awareness of their ecological value. These waterbodies, whether natural like Sakhya Sagar or man-made like Sirpur Lake, provide essential ecosystem services and support rich biodiversity, particularly for birds. This recognition acknowledges that diverse types of wetlands are critical for environmental health and signals a committed effort to manage these resources sustainably under international conservation frameworks.

129. (B) Lameta Formation near Jabalpur
Raja Narmadensis, a large carnivorous dinosaur, was discovered in the late Cretaceous Lameta Formation near Jabalpur. This sedimentary unit is globally famous for its wealth of dinosaur remains, providing essential evidence for understanding Mesozoic terrestrial life in central India. The discovery highlights the importance of the Narmada Valley as a premier paleontological research area, offering insights into the diversity and final stages of dinosaur evolution before their mass extinction event.

130. (A) Both Statement I and Statement II are correct.
The Narmada and Tapti rivers both flow through parallel tectonic rift valleys or grabens. The uplifted block of land between these two structural troughs is the Satpura Range, which serves as a classic example of a horst. This structural arrangement is a result of extensional

forces that have shaped the central Indian landscape, creating a dramatic topography of alternating deep valleys and elevated mountain ranges trending roughly east-west.

131. (C) Coal
The primary economic importance of the Gondwana stratigraphic units in Madhya Pradesh lies in their extensive coal seams. These continental sedimentary basins host some of the largest coal deposits in India, particularly in the eastern districts. This coal is the essential fuel for numerous thermal power plants and various industrial processes. The Gondwana rocks thus form the bedrock of the state's energy sector and are vital for regional and national economic development.

132. (D) Bhoj Wetland
The Bhoj Wetland is a prominent Ramsar site located in the city of Bhopal. Consisting of the Upper and Lower Lakes, it serves as a critical ecosystem and a primary source of water for the urban population. Its designation under the Ramsar Convention highlights its international importance for biodiversity and underscores the necessity of conserving urban wetlands as vital components of the environmental and social infrastructure of the state capital.

133. (C) Protection from elements and a vantage point for game.
The rock shelters at Bhimbetka were ideal for prehistoric humans because they offered natural protection from rain, sun, and predators. Additionally, their elevated position on the Vindhyan foothills provided a clear vantage point for observing migratory animals and tracking game in the plains below. This combination of shelter and strategic location supported continuous human habitation and the development of a vibrant hunter-gatherer culture over thousands of years in central India.

134. (D) Bagh Caves
While Ghughwa, Lameta Ghat, and the Narmada Valley sites are primarily renowned for their fossil records, including plants, dinosaurs, and early hominids, the Bagh Caves are famous for their rock-cut architecture and murals. The Bagh Caves represent a significant geoarchaeological site focused on human creativity and religious history rather than paleontological remains. This distinction highlights the diverse nature of Madhya Pradesh's heritage sites, which include both fossil-rich formations and ancient human monuments.

135. (A) Panna
The Majhgawan diamond mine, operated by the National Mineral Development Corporation, is located in the Panna district. It is the only operational commercial diamond mine in India, extracting gemstones from a primary kimberlite pipe. This mine is the cornerstone of India's diamond industry, reflecting the unique geological conditions of the Panna region that allowed diamonds to be brought from the Earth's mantle to the surface billions of years ago.

136. (B) The Balancing Rock of Jabalpur
The Balancing Rock in Jabalpur is a quintessential example of a natural 'Rock Monument.' It was formed through the long-term weathering of a massive granitic block, leaving a large boulder perfectly balanced on another. This unusual landform is a major geotourism attraction, showcasing the power of natural erosive processes to create scientifically interesting and aesthetically pleasing features. Unlike man-made monuments like Sanchi, it is a product of geological history and environmental forces.

137. (A) Layers of sand, silt, and gravel
In the alluvial provinces along the Narmada River, groundwater is primarily found within unconsolidated layers of sand, silt, and gravel. These sediments, deposited by fluvial processes, possess high primary porosity and permeability, making them excellent aquifers. These systems can store and transmit large volumes of water, supporting intensive agriculture and providing reliable domestic water supplies. The nature of these alluvial deposits makes them highly productive compared to the surrounding hard-rock formations.

138. (C) Vindhyan Supergroup
The concentration of cement industries in the Satna-Rewa-Katni belt is a direct result of the high-quality limestone found in the Vindhyan Supergroup. This Proterozoic sedimentary sequence contains extensive and accessible limestone beds that serve as the primary raw

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Siberia visit the lake during the winter months. The conservation of this site is essential for maintaining regional avian biodiversity and highlights how even man-made waterbodies can develop significant ecological value when properly managed and protected within an urban landscape.

154. (B) The growth rings and cellular structure of the trees.
The plant fossils at Ghughwa are exceptionally well-preserved through the process of permineralization. This level of preservation is so detailed that scientists can examine the original growth rings and cellular structures of ancient trees. These features allow researchers to reconstruct the growth patterns and environmental conditions of the late Cretaceous period, providing a precise biological record of the flora that existed in central India before the Deccan Traps eruptions.

155. (B) East-West
The structural trend of the Narmada Rift Valley is predominantly east-west. This orientation is defined by the deep-seated Narmada-Son Lineament, which cuts across the central Indian shield. The alignment of the river, the bounding faults of the graben, and the adjacent Satpura and Vindhyan ranges all follow this fundamental tectonic grain. This east-west orientation has historically influenced the drainage patterns, climate, and human movement across the heart of the Indian subcontinent.

156. (C) Gully erosion by fluvial processes
The 'badland topography' of the Chambal Valley is a classic example of extreme gully erosion caused by fluvial processes. In this semi-arid region, concentrated runoff from rainfall has carved deep, narrow channels into thick alluvial deposits. Over time, these gullies have expanded into an intricate network of ravines. This process is driven by the region's specific soil characteristics, relief, and rainfall patterns, creating a landscape that is both geologically unique and agriculturally challenging.

157. (C) Petroleum Refining
While Madhya Pradesh has a thriving industrial sector based on coal, limestone, and bauxite, it has a very limited presence in petroleum refining. The state's geology is dominated by ancient crystalline and sedimentary basins that have not yielded significant commercial petroleum or natural gas reserves. Consequently, most oil and gas used in the state are imported or processed elsewhere, unlike the well-established cement, thermal power, and aluminum industries based on local mineral resources.

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158. (B) Historical hydrogeology or hydro-archaeology
The study of ancient man-made waterbodies like Bhojtal and the tanks of Bundelkhand falls under historical hydrogeology or hydro-archaeology. These fields examine how past civilizations understood and managed water resources through engineering and landscape modification. By studying these ancient structures, researchers can learn about historical rainfall patterns, groundwater use, and sustainable management techniques, providing valuable lessons for modern water security and conservation in the context of the region's specific geological setting.

159. (B) A series of man-made rock-cut monastic dwellings.
The Bagh Caves are an important geoarchaeological site representing ancient man-made rock-cut architecture. These nine monuments were carved into sandstone cliffs to serve as Viharas or monastic retreats for Buddhist monks. Unlike natural caverns, they were meticulously engineered to include living quarters and prayer halls. The intersection of human craftsmanship and regional sedimentary geology at Bagh provides a significant historical record of religious and social life during the Gupta and Vakataka periods.

160. (B) Conservation, Education, and Sustainable Development (Geotourism)
The success of a Geopark depends on the integration of three core pillars: conservation of geodiversity, public education about geological processes, and the promotion of sustainable economic development through geotourism. By protecting unique geological sites while making them accessible and educational for visitors, a Geopark fosters a deeper appreciation for natural heritage and provides long-term benefits to local communities, ensuring that geological preservation and economic growth work together harmoniously.

social organization over thousands of years, making it an irreplaceable treasure of global archaeological and geological heritage.

146. (B) Gondwana Supergroup
A geologist investigating the Satpura basin would primarily focus on the Gondwana Supergroup. This basin is a major structural feature in Madhya Pradesh filled with thick sequences of continental sedimentary rocks, including sandstones, shales, and extensive coal seams. Deposited during the late Paleozoic and Mesozoic eras, the Gondwana sequence in the Satpura region is essential for understanding ancient continental environments and is a major source of the state's energy and mineral resources.

147. (C) Tawa Reservoir
The Tawa Reservoir is a modern man-made reservoir created by constructing a large dam across the Tawa River for irrigation and power generation. Unlike the Bhoj Wetland, which has an ancient history, or Sakhya Sagar and Sirpur Lake, which are designated Ramsar sites recognized for their international ecological importance, Tawa is primarily an engineering and water management project. This distinction highlights the diverse types of human-engineered waterbodies that characterize the hydrogeological landscape of Madhya Pradesh.

148. (B) The variety of geological, geomorphological, and soil features and processes.
Geodiversity refers to the natural variety of non-living features of the Earth's surface and interior. This includes the state's diverse rock types, fossils, landforms like canyons and plateaus, and the geological processes that form them, such as volcanism or fluvial erosion. In Madhya Pradesh, high geodiversity is reflected in its vast chronological range of rocks and its unique tectonic features, providing the foundation for the state's diverse ecosystems, mineral wealth, and cultural heritage.

149. (C) The extinction of the dinosaurs at the Cretaceous-Paleogene boundary
The massive volcanic eruptions that formed the Deccan Traps in Madhya Pradesh occurred during the late Cretaceous and early Paleogene. This period of intense volcanic activity coincides with the major global mass extinction event that wiped out the dinosaurs. Scientists study these lava flows to understand how such large-scale volcanic events contributed to global climatic changes and the transition between these two geological eras, making the Deccan Traps a site of global scientific importance.

150. (A) Balancing tourism development with the need for site conservation.
A major challenge for geotourism in Madhya Pradesh is ensuring that increased public access to unique geological sites does not lead to their degradation. Irreplaceable features like fossils at Ghughwa or rock art at Bhimbetka are vulnerable to environmental weathering and human impact. Effective management must prioritize conservation through education and regulation while still promoting the economic benefits of tourism, requiring a careful and scientifically guided approach to site development.

151. (B) Upper units of the Vindhyan Supergroup
The upper units of the Vindhyan Supergroup, particularly within the Bhander and Rewa groups, are major sources of flagstones and roofing slate. These sedimentary rocks naturally occur in thin, horizontally bedded layers that can be easily quarried into flat slabs. Their durability, varied colors, and ease of working have made them a traditional and modern choice for building materials, demonstrating how regional stratigraphy directly supports local construction industries in Madhya Pradesh.

152. (B) Chalcopyrite in quartz reefs
The copper mineralization at the Malanjkhand mine is primarily found in the form of chalcopyrite hosted within large quartz reefs. These reefs intrude into ancient granitic rocks, creating a massive, low-grade ore body suitable for open-cast mining. Chalcopyrite is the most important copper-bearing mineral, and its presence in Malanjkhand makes the site one of India's premier sources of copper, contributing significantly to the national mineral output and industrial supply chain.

153. (A) Migratory birds
Sirpur Lake in Indore is a critical urban wetland recognized as a Ramsar site primarily for its role as a habitat for migratory birds. Every year, thousands of birds from Central Asia and

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material for cement production. The regional availability of this essential mineral, combined with nearby coal resources, has established this belt as one of the most significant hubs for construction materials in India.

139. (D) The entire state is part of a tectonically stable, inactive shield.
While Madhya Pradesh is part of the Indian shield, it is not entirely tectonically inactive. The state features significant structural features like the Narmada Graben, the Satpura Horst, and the Narmada-Son Lineament. These zones have experienced periodic seismic activity and reactivation of ancient faults. The idea of total inactivity is incorrect, as the regional geology is defined by ongoing stresses within the Indian plate that periodically manifest as modern tectonic and seismic events.

140. (A) Ghughwa has plant fossils, while Narmada Valley is known for animal and hominid fossils.
A fundamental difference between these two major fossil regions is their primary paleontological focus. Ghughwa is world-famous for its well-preserved petrified plant remains, including tree trunks and seeds from the late Cretaceous. In contrast, the Narmada Valley is primarily renowned for its animal fossils, including diverse Pleistocene mammals and rare hominid remains like the Narmada Man. This variety provides a comprehensive understanding of the prehistoric biodiversity of central India across different geological eras.

141. (B) Sustainable utilization of wetland resources for humans and ecosystems.
The 'wise use' principle of the Ramsar Convention encourages the sustainable utilization of wetlands. This means managing these ecosystems in a way that provides essential services to humans, such as water and food, while ensuring that the natural biological diversity and ecological processes are maintained. It is not about total prohibition but about achieving a balance that allows for sustainable development without compromising the integrity of the wetland for future generations.

142. (D) Gupta-Vakataka period (circa 5th-6th century AD)
The murals and architecture of the Bagh Caves provide invaluable insights into the life and culture of the Gupta-Vakataka period. These rock-cut Buddhist monasteries were decorated with elaborate tempera paintings depicting religious narratives and secular scenes of courtly life. From a geoarchaeological perspective, they illustrate how historical societies used regional geological materials to create enduring monuments that reflect the sophisticated artistic and religious traditions of one of India's most significant historical eras.

143. (A) Volcanic pipes of kimberlite and conglomerate deposits.
In the Panna region, diamonds are geologically associated with primary volcanic pipes of kimberlite and secondary sedimentary conglomerate deposits. These diamonds originated deep within the Earth's mantle and were brought to the surface by explosive volcanic eruptions billions of years ago. Some were later eroded and redeposited in younger conglomerate layers. This unique geological setting makes Panna the only area in India where diamonds are currently mined on a large commercial scale.

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144. (B) Weathered, vesicular, or fractured.
Deccan Basalt is inherently a dense, low-porosity rock that typically acts as a barrier to water. However, it can become a productive aquifer if it is significantly weathered, contains volcanic vesicles (gas bubbles), or is intensely fractured by tectonic activity. These features create secondary porosity and permeability, allowing the rock to store and transmit groundwater. In the absence of such secondary features, the basalt remains impermeable, leading to high surface runoff and limited infiltration.

145. (A) The density and long duration of prehistoric rock art.
Bhimbetka's UNESCO World Heritage status is based on its outstanding universal value as one of the world's most significant prehistoric sites. It features a massive density of rock art that spans from the Upper Paleolithic through the Mesolithic and into the historic period. This continuous record provides unparalleled evidence of human cultural evolution, subsistence strategies, and

161. (C) Archaean
The basement rocks that form the ancient foundation of Madhya Pradesh belong to the Archaean Eon. These crystalline rocks, primarily gneisses and granites, represent some of the earliest crust formed on Earth, dating back over two and a half billion years. They underlie the younger sedimentary basins and volcanic plateaus of the state, serving as the stable platform or craton upon which the entire geological history of the region was subsequently built.

162. (A) Both Statement I and Statement II are correct.
The Panna region is unique in India as the only area where diamonds are currently extracted on a commercial scale. These gemstones are primarily sourced from ancient kimberlite pipes that formed during the Precambrian era. These volcanic pipes brought diamonds from the Earth's mantle to the surface billions of years ago. The discovery and continued mining of these deposits make Panna a critical site for both the national economy and global geological study.

163. (D) Infiltration of rainfall
In most parts of Madhya Pradesh, the primary source of groundwater recharge is the direct infiltration of monsoon rainfall. Rainwater percolates through the soil and into the underlying rock formations, accumulating in weathered zones, fractures, and porous sedimentary layers. This process is essential for replenishing the state's various aquifers. However, factors like local lithology, topography, and land cover significantly influence how much rainfall successfully recharges the groundwater systems across different regions.

164. (B) Paleo-anthropology and Archaeology
The rock art at Bhimbetka provides invaluable data for paleo-anthropology and archaeology. By depicting scenes of hunting, dancing, and social rituals, the paintings offer a visual record of prehistoric human behavior, technology, and social structures. Researchers use these images to reconstruct the daily lives and cultural evolution of ancient populations in central India. This artistic sequence serves as a primary source for understanding the long-term human history preserved within the state's geological shelters.

165. (B) Differential weathering and erosion of granitic rocks
Unique landforms like inselbergs and tors in the Bundelkhand region are the results of differential weathering and erosion of ancient granitic rocks. Resistant blocks of granite remain as isolated hills or piles of boulders while the surrounding, less resistant material is eroded away. These features provide a dramatic landscape and serve as important geoheritage sites, illustrating how variations in rock resistance and environmental forces shape the surface of the ancient Indian craton over millions of years.

166. (D) Uranium
While Madhya Pradesh is rich in coal, manganese, and limestone, it is not currently a significant producer of uranium. These other minerals form the backbone of the state's industrial sector, supporting power generation, steel production, and the cement industry. While exploration for various minerals continues, uranium remains a less prominent resource in the state's current economic portfolio compared to its massive reserves of coal and industrial sedimentary and metamorphic minerals.

167. (B) Man-made reservoir created on the Manier river
Sakhya Sagar is a man-made reservoir located within Madhav National Park in Shivpuri. It was created in the early twentieth century by constructing a dam across the Manier River. Recently designated as a Ramsar site, it has developed into a vital wetland ecosystem that supports a wide range of biodiversity, including mugger crocodiles and numerous bird species. It exemplifies how human engineering can create ecologically significant habitats that merit international conservation recognition.

168. (A) Cenozoic mammals and hominids
The fossils found in the Narmada Valley primarily belong to the Cenozoic era, with a focus on the Pleistocene epoch. These finds include diverse mammals such as ancient elephants, hippos, and bovines, alongside critical hominid remains like the Narmada Man. This rich record helps scientists understand the evolution of vertebrate fauna and early human history in South Asia, providing a detailed view of the regional

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water supply, do not compromise the biodiversity and ecological processes of the ecosystem. It is a critical approach for ensuring long-term environmental sustainability and water security for the population of Bhopal.

214. (A) On the inner walls and ceilings, protected from direct rain.
The rock art at Bhimbetka is primarily located on the inner walls and ceilings of the sandstone shelters. These positions were chosen by prehistoric artists because they were naturally protected from direct rainfall and excessive sun exposure. This strategic placement has been essential for the remarkable preservation of the ancient pigments over thousands of years. The geology of the shelters thus provided both the canvas and the protective environment needed for this unique record to survive.

215. (A) Homo erectus
The fossil skull cap discovered at Hathnora in the Narmada Valley, popularly known as 'Narmada Man,' is attributed to the species Homo erectus. This find is world-renowned as one of the few middle Pleistocene hominid fossils found in South Asia. It provides critical evidence for the presence and evolution of early human ancestors in the Indian subcontinent. The fossil's discovery highlights the Narmada Valley's status as a major international site for paleoanthropological and geoarchaeological research.

216. (A) A sheet-like body of igneous rock that cuts across the bedding of older rocks.
A dyke is a sheet-like body of igneous rock that forms when magma is forced into a fracture in pre-existing rock, cutting across its bedding or foliation. The Great Dyke of Gwalior is a prominent example of such an intrusive feature. These structures provide valuable information about the tectonic stresses and volcanic activity that occurred in the Earth's past. They are essential features in the study of regional geology and the thermal evolution of the state's ancient crust.

217. (A) Coal
The large-scale newsprint manufacturing industry at NEPA Limited requires significant amounts of thermal and electrical power. This energy is primarily supplied by coal-fired power plants. Coal is an essential mineral resource for such industrial operations in Madhya Pradesh, where its abundance in the Gondwana basins supports the energy-intensive processing of forest-derived raw materials. This highlights how various industrial sectors, even those based on forestry, are ultimately dependent on the state's underlying geological mineral wealth.

218. (A) Alluvial provinces
The alluvial provinces along major rivers like the Narmada and Chambal are most susceptible to groundwater contamination. This is because the unconsolidated sediments, such as sand and gravel, have high porosity and permeability, allowing for the rapid infiltration of water from the surface. Consequently, chemical fertilizers and pesticides used in agriculture can easily percolate down to the water table, necessitating careful management of agricultural practices to protect the quality of these productive and vital regional aquifers.

219. (A) Many of the original nine caves have collapsed or are in poor condition.
The geoarchaeological significance of the Bagh Caves is compromised by the poor preservation state of several monuments. Due to the weak nature of the host sandstone and long-term environmental weathering, many of the original caves have collapsed or suffered extensive structural damage. These natural geological challenges have led to the loss of much of the ancient architecture and murals, emphasizing the urgent need for specialized conservation efforts to protect the remaining monuments of this historical Buddhist site.

220. (A) Damaging or allowing the theft of scientifically important fossils.
Promoting geotourism in the Narmada Valley requires careful planning to protect its irreplaceable fossil record. Fossil sites are highly vulnerable to damage from unregulated foot traffic and the illegal theft of specimens by collectors. Effective management must involve site protection, public education, and strict regulation to ensure that these scientifically important resources are preserved for research and future generations. Balancing tourism with the rigorous conservation of geodiversity is

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of continental basins where thick sequences of sandstone, shale, and coal were accumulated. Correctly identifying these geological ages is essential for reconstructing the assembly of the Indian subcontinent and understanding the timing of the environmental changes that led to the formation of its major mineral resources.

177. (C) Deccan Traps (Basalt)
The industrial hub of Pithampur is located on the Malwa plateau, which is geologically dominated by the Deccan Traps. These volcanic basalt flows provide solid foundations for construction but are not the source of minerals like coal, limestone, or copper. Consequently, large-scale mineral-based industries in this region must source their raw materials from other parts of Madhya Pradesh where those specific stratigraphic units are exposed, highlighting the regional specialization of mineral resources in the state.

178. (A) Scientific research, education, and fostering a sense of geological heritage.
Protecting Geoheritage sites in Madhya Pradesh is crucial for advancing scientific research and providing educational opportunities. These sites represent irreplaceable records of Earth's history, including ancient climates, evolution, and tectonic movements. By conserving them, the state also fosters a sense of pride and awareness regarding its unique natural heritage. This approach ensures that future generations can learn from and appreciate the geological processes that have shaped their regional environment and resources.

179. (B) The only hominid fossil from the Middle Pleistocene found in the subcontinent.
The discovery of the Narmada Man (Homo erectus) at Hathnora is of immense scientific importance. It represents the only hominid fossil found in the Indian subcontinent dating to the Middle Pleistocene period. This find provides a critical link in understanding early human evolution and dispersal across South Asia. The fossil's context within the fluvial sediments of the Narmada Valley highlights the region's role as a major corridor for ancient human migration and environmental adaptation.

180. (C) Controlled, sustainable geotourism
Controlled and sustainable geotourism is not a threat to the hydrogeology or waterbodies of Madhya Pradesh; rather, it can promote their conservation. Threats come from over-extraction of groundwater, pollution from industrial and domestic sources, and the siltation of reservoirs. By contrast, well-managed geotourism provides educational opportunities and financial support for the protection of these sites, encouraging a balance between human use and the preservation of the state's vital water and geological resources.

181. (B) Vindhyan Supergroup
The Vindhyan Supergroup is a classic example of the principle of horizontality in stratigraphy. Over large areas of central and northern Madhya Pradesh, its sedimentary layers have remained remarkably flat-lying and undisturbed for over a billion years. This horizontal bedding demonstrates the stability of the Vindhyan basin and makes the rock easy to quarry in consistent slabs, supporting its widespread use as a primary building material across the region for centuries.

182. (A) Balaghat
Balaghat is often referred to as the 'Manganese City' because of its proximity to the Bharveli mine, Asia's largest and deepest underground manganese source. The district is a major global hub for manganese production, which is essential for the iron and steel industries. This title reflects the overwhelming dominance of manganese mining in the local economy and the district's specific geological wealth, which is centered on the ancient metamorphic rocks of the Sausar Group.

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183. (C) I is correct, but Statement II is incorrect.
The Ramsar Convention is an international treaty dedicated to the conservation and sustainable use of wetlands. While Statement I is correct, Statement II is incorrect because Madhya Pradesh has four recognized Ramsar sites: the Bhoj Wetland, Sakhya Sagar, Sirpur Lake, and Yashwant Sagar. These designations highlight the state's active participation in international efforts to protect its diverse and ecologically significant wetlands, which serve as vital habitats for migratory waterfowl and other wildlife.

humans. From simple Lower Paleolithic choppers to sophisticated Mesolithic microliths, these artifacts reflect changes in subsistence strategies and human adaptation to varying environments over hundreds of thousands of years. This archaeological record, preserved within the valley's geological strata, makes the Narmada Valley a benchmark site for studying the deep history of human development in South Asia.

200. (A) In-situ and ex-situ conservation of paleontological heritage for science and education.
Fossil Parks in Madhya Pradesh are established with the primary purpose of conserving paleontological remains for scientific study and public education. These parks protect fossils either in their original discovery locations (in-situ) or in specialized museum facilities (ex-situ). By preserving unique records of ancient life, such as dinosaurs or petrified plants, these parks serve as valuable research sites and educational tools, fostering an understanding of Earth's history and the evolution of biodiversity across different geological eras.

201. (A) Deformed and metamorphosed volcanic and sedimentary rocks.
The Mahakoshal Group, found along the Narmada-Son Lineament, consists of a complex sequence of deformed and metamorphosed volcanic and sedimentary rocks. These rocks date back to the Proterozoic Eon and reflect a period of intense tectonic activity and crustal evolution. Their presence within this major structural zone is significant for understanding the geological assembly of central India. The group often hosts various mineral deposits, making it an area of interest for both scientific research and mineral exploration.

202. (A) Their primary raw material is not a geological mineral.
While the Security Paper Mill and Bank Note Press are major industries, they are not classified as 'mineral-based' because their primary raw material is specialized paper pulp rather than a geological mineral. In contrast, a cement plant is directly dependent on limestone, and an aluminum plant on bauxite. This distinction is based on the industry's direct reliance on the state's geological resources, highlighting the specific contribution of minerals to the regional economic and industrial structure of Madhya Pradesh.

203. (A) A multi-layered system of sand and clay, forming productive aquifers.
The Narmada alluvial plain is characterized by a complex, multi-layered hydrogeological system. It consists of alternating layers of porous sand and gravel separated by impermeable clay. These sand and gravel layers form highly productive aquifers capable of storing and transmitting large volumes of groundwater. This system is essential for supporting intensive agriculture and providing reliable water supplies for the numerous towns and cities located along the Narmada Valley, making it a critical regional water resource.

204. (C) Clay-rich sandstone
The Bagh Caves were carved into a specific type of clay-rich sandstone that is relatively soft and susceptible to erosion. This geological characteristic has posed a significant challenge for the long-term preservation of the rock-cut monuments. Over time, exposure to moisture and environmental factors has caused the sandstone to deteriorate, threatening both the structural stability of the caves and the ancient murals they contain. Ongoing conservation efforts focus on managing these inherent geological vulnerabilities.

205. (A) The United Nations Educational, Scientific and Cultural Organization (UNESCO)
The concept of a Geopark is promoted globally by UNESCO through its International Geoscience and Geoparks Programme. UNESCO Geoparks are single, unified geographical areas where sites and landscapes of international geological significance are managed with a holistic concept of protection, education, and sustainable development. This international framework supports states like Madhya Pradesh in recognizing, protecting, and promoting their unique geological heritage for the benefit of both science and local communities through responsible geotourism.

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Eon. Their presence indicates that microbial life was widespread and played a key role in sediment deposition long before the emergence of complex multicellular organisms. This makes the Vindhyan rocks an essential resource for studying the early biological and environmental history of the planet.

192. (B) Manganese
Manganese is an essential mineral for several modern industries, and Madhya Pradesh is a leading producer in India. It is a critical component in the production of dry cell batteries and ferro-alloys used in steelmaking. The high-quality manganese ore from mines like Bharveli in the Balaghat district supports these industrial sectors, contributing to national industrial capacity and fulfilling critical demands for energy storage and advanced metal manufacturing in the state and beyond.

193. (B) The Bhoj Wetland (Upper Lake)
Lake eutrophication, caused by an overabundance of nutrients from urban runoff and sewage, is a major threat to the Bhoj Wetland in Bhopal. This process leads to excessive algae growth, which depletes oxygen levels and harms aquatic life. As a designated Ramsar site and a primary water source, managing this environmental challenge is critical for the ecological health of the lake and the continued security of the city's water supply.

194. (A) A deeply eroded structural valley
Patalkot is a unique geomorphological feature consisting of a deep, horseshoe-shaped valley in the Chhindwara district. It was formed by the deep erosion of the regional landscape, exposing ancient Gondwana rocks. The valley's isolation has preserved a distinct ecological and cultural environment for the local tribal communities. From a geological perspective, it provides an excellent example of how fluvial erosion and structural control can create dramatic relief and isolated ecosystems within the central Indian plateau.

195. (A) Sandstone
The rock shelters of Bhimbetka are composed of durable Vindhyan sandstone. This rock provided an ideal 'canvas' for prehistoric artists because its surface is relatively smooth and resistant to weathering compared to other rock types. The natural overhangs and shelters formed in this sandstone provided protected spaces where paintings could survive for thousands of years. The durability of the sandstone is a key factor in the remarkable preservation of this world-unique record of human cultural evolution.

196. (C) The Narmada Rift Valley
The Narmada Rift Valley acts as the primary tectonic divider between the Vindhyan and Satpura mountain ranges in Madhya Pradesh. This deep-seated graben was formed by the faulting of the Earth's crust, creating a low-lying trough through which the Narmada River flows westward. To the north lies the Vindhyan range, and to the south lies the Satpura range, illustrating a dramatic structural landscape defined by alternating blocks of uplifted horsts and down-dropped grabens across central India.

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197. (A) Use minerals as their primary raw material.
Mineral-based industries are specifically defined as those that utilize minerals or geological resources as their primary raw material for manufacturing. Examples include cement plants using limestone, aluminum plants using bauxite, and thermal power plants using coal. Madhya Pradesh has a strong foundation in these sectors due to its extensive and diverse mineral wealth. These industries drive the state's economic growth and provide essential materials for national infrastructure, energy production, and various industrial supply chains.

198. (B) During the Mughal period (18th Century)
The Lower Lake of Bhopal, which is part of the Bhoj Wetland ecosystem, is believed to have been created in the eighteenth century during the Mughal period. It was formed by damming the outflow from the Upper Lake to provide additional water storage and aesthetic value to the city. While younger than the eleventh-century Upper Lake, it remains an integral part of the city's hydro-heritage and ecological framework, contributing to the local biodiversity and urban environment.

199. (A) Understanding the evolution of technology and human adaptation over millennia.
The continuous sequence of stone tools found in the Narmada Valley is crucial for understanding the long-term technological evolution of early

environments during a period of significant evolutionary change.

169. (A) Tensional force
A graben, such as the Narmada Valley, is formed by tensional forces within the Earth's crust. These forces pull the crust apart, causing a block of land to drop down between parallel normal faults. In central India, this extensional tectonics created the deep structural trough through which the Narmada River flows. Understanding these forces is essential for reconstructing the tectonic history of the Indian plate and explaining the regional drainage patterns and modern seismic activity.

170. (C) Deccan Basalt
The black cotton soil, or regur, found extensively on the Malwa plateau is a direct product of the chemical weathering of Deccan Basalt. These volcanic rocks are rich in iron, magnesium, and calcium, which contribute to the soil's fertility and its characteristic dark color. The high clay content of this soil makes it excellent for retaining moisture, supporting the intensive cultivation of crops like cotton and soybean, which are vital to the agricultural economy of Madhya Pradesh.

171. (B) Coal
The districts of Sidhi and Singrauli are part of the massive Gondwana basin, which is world-renowned for its vast coal deposits. These sedimentary formations contain thick seams of thermal coal formed from ancient plant matter in continental basins. The extraction of coal in this region fuels several large thermal power plants, making it a critical energy hub for India. The local geology thus directly dictates the industrial and economic character of this part of Madhya Pradesh.

172. (A) Understanding historical water management techniques and their potential application today.
Conserving man-made ancient waterbodies is vital for learning about historical water management. These structures demonstrate how past societies successfully harvested and stored water by working with the local geology and climate. Understanding these traditional techniques can provide sustainable and low-cost solutions for modern water security challenges. Preserving these sites as both cultural and hydrogeological heritage helps maintain regional water tables and provides educational resources for future resource planning in Madhya Pradesh.

173. (A) A waterfall created by the Narmada river plunging over resistant marble rocks.
The Dhuandhar Falls is a spectacular geomorphological feature formed where the Narmada River drops over a cliff of resistant Precambrian marble. The sheer force of the water falling into a deep plunge pool creates a mist that resembles smoke, giving the falls its name. This site showcases the dynamic power of fluvial erosion and its interaction with the regional metamorphic geology, making it one of the most famous geotourism destinations in Madhya Pradesh.

174. (D) The friable nature of the sandstone in which they are carved and water percolation.
The preservation of the Bagh Caves is a significant challenge due to the geological characteristics of the host rock. The caves were carved into a relatively weak and friable sandstone that is susceptible to erosion and collapse. Additionally, water percolation through the rock layers can damage the ancient murals and weaken the structural integrity of the monuments. Ongoing conservation efforts are necessary to manage these natural geological threats and preserve this unique geoarchaeological heritage.

175. (A) Diverse and accessible geological formations, fossil sites, and landforms.
Madhya Pradesh's strong prospect for geotourism is built on its remarkable variety of geological features. From ancient rock shelters at Bhimbetka to stunning marble gorges and dinosaur fossil sites, the state offers a wide range of accessible and scientifically significant landscapes. This diversity allows for the development of diverse tourism experiences that combine natural beauty with education about the Earth's history, positioning the state as a leading destination for geological and environmental travel in India.

176. (C) Gondwana Supergroup - Paleozoic to Mesozoic
The Gondwana Supergroup was deposited during the late Paleozoic and Mesozoic eras, roughly between three hundred and sixty-five million years ago. This period saw the formation

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206. (A) Both Statement I and Statement II are correct.
The Narmada is significantly longer than the Tapti, but both rivers are unique in the Indian subcontinent for their westward flow. Each river is constrained within a tectonic rift valley or graben formed by major fault zones. They both cross the peninsular shield to empty into the Arabian Sea. This parallel structural arrangement and shared drainage direction highlight the dominant role of extensional tectonics in shaping the regional landscape and hydrology of central India.

207. (B) Dolomite
Dolomite is mined in Madhya Pradesh for several critical industrial applications. In the steel industry, it is used as a flux to remove impurities during smelting. Additionally, it serves as an important source of magnesium. Found in various stratigraphic units like the Vindhyan and Sausar groups, dolomite deposits are vital for the state's mineral-based economy, supporting regional metal manufacturing and contributing to various chemical and agricultural industrial processes.

208. (A) Man-made reservoir constructed in the early 20th century.
Sakhya Sagar, now a designated Ramsar site, is a man-made reservoir located within Madhav National Park. It was constructed on the Manier River in the early twentieth century to serve as a reliable water source. Over decades, it has evolved into a vital wetland ecosystem that supports a diverse range of wildlife. Its recognition under the Ramsar Convention underscores how historically engineered waterbodies can become internationally significant habitats for biodiversity conservation and environmental sustainability.

209. (A) The cultural and technological evolution over thousands of years.
The diverse styles of rock art at Bhimbetka, ranging from simple stick figures to elaborate scenes of warfare on horseback, illustrate a remarkable cultural and technological evolution. These paintings record the transition of prehistoric societies through different stages of development, from hunter-gatherer groups to more complex social structures. By analyzing this artistic sequence, researchers can trace the long-term history of human interaction, social changes, and technological progress preserved within the state's natural sandstone shelters.

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210. (A) Precambrian marbles, Cretaceous dinosaur fossils, and Deccan Traps.
The Bhedaghat-Lametaghat area is a premier candidate for a Geopark because it brings together three major geological stories in one location. Visitors can see ancient Precambrian marbles, significant dinosaur fossils from the Cretaceous Lameta Formation, and the remnants of the Deccan Trap lava flows. This unique juxtaposition allows for a comprehensive educational experience about Earth's history, ranging from ancient metamorphism and Mesozoic terrestrial life to massive volcanic events that shaped the Indian subcontinent.

211. (A) The ancient Archaean and Proterozoic crystalline rocks upon which younger sediments were deposited.
In the geology of Madhya Pradesh, the 'basement complex' refers to the ancient crystalline rocks of Archaean and Proterozoic age. These granites, gneisses, and schists form the stable crustal foundation of the state. Younger sedimentary sequences like the Vindhyan and Gondwana, as well as the Deccan Traps, were deposited on top of this stable platform. Understanding the basement complex is essential for reconstructing the state's earliest geological history and the structural evolution of the Indian shield.

212. (A) Coal
The Umaria and Shahdol districts are key regions for coal mining in Madhya Pradesh. They are part of the extensive Gondwana sedimentary basins that host significant reserves of thermal coal. The extraction of this mineral is a major economic driver for the region, supplying fuel for numerous power plants and industrial sectors. The presence of these coal deposits is a direct consequence of the region's specific geological history during the late Paleozoic and Mesozoic eras.

213. (A) The 'wise use' concept.
Managing the Bhoj Wetland involves the 'wise use' concept, which balances the city's urban water needs with the ecological health of the Ramsar site. This principle promotes the sustainable utilization of wetland resources so that human benefits, such as a reliable drinking

184. (B) Protect and preserve the in-situ paleobotanical fossils.
The Ghughwa Fossil Park was established primarily to protect and preserve its world-class collection of petrified plant remains in their natural discovery locations. This 'in-situ' conservation approach allows scientists and the public to observe fossils, such as tree trunks and seeds, exactly where they were deposited sixty-five million years ago. The park serves as a critical site for scientific research, education, and the conservation of the state's unique paleobotanical geoheritage.

185. (B) The Precambrian era
The Son-Narmada-Tapti lineament system is an ancient zone of crustal weakness that has been tectonically active since the Precambrian era. This deep-seated fault system has influenced sedimentation, igneous activity, and modern seismicity across central India for billions of years. Its long history of activity demonstrates that the Indian shield is composed of distinct blocks that have repeatedly moved and interacted along these fundamental structural zones, shaping the region's complex geological and topographic evolution.

186. (C) Cement industry
The cement industry is arguably the largest mineral-based industry in Madhya Pradesh in terms of bulk material consumed. It relies on the massive extraction of limestone from the Vindhyan Supergroup, as well as significant quantities of coal and gypsum. The presence of these resources in abundance, particularly in the Satna-Rewa belt, has made the state a national leader in cement production, driving substantial economic growth and supporting large-scale infrastructure projects across the country.

187. (C) A mix of Buddhist religious and courtly secular themes
The art of the Bagh Caves is notable for its blend of religious and secular themes. While the caves served as Buddhist monasteries, the paintings depict not only Jataka tales but also scenes of courtly life, music, and dance. This mix provides a rich view of the social and cultural environment of the Gupta and Vakataka periods. It highlights the integration of spiritual and mundane life in ancient India as preserved within the state's geoarchaeological monuments.

188. (B) Low storage capacity of aquifers and dependency on fracture systems.
A major hydrogeological challenge in the Bundelkhand region is the crystalline nature of the basement rocks. Hard rocks like granite and gneiss have very low primary porosity, leading to low storage capacity in aquifers. Consequently, groundwater availability is entirely dependent on the presence of secondary features like fractures and weathered zones. This makes water supplies unreliable, especially during the summer, as these limited storage systems can be rapidly depleted by over-extraction for agriculture and domestic use.

189. (A) It must contain significant geological heritage and a plan for sustainable management.
To be recognized as a National Geopark, a site must possess geological features of significant heritage value and have a clear plan for its sustainable management. This includes strategies for conservation, public education, and the promotion of geotourism to benefit the local economy. The Geopark concept emphasizes the connection between geological heritage and the broader natural and cultural landscape, ensuring that unique sites are protected while providing educational and economic value.

190. (A) A nesting and breeding ground for dinosaurs.
The discovery of numerous dinosaur egg clutches and nests in the Lameta beds suggests that the Narmada Valley served as an extensive nesting and breeding ground during the late Cretaceous. These finds provide critical evidence regarding dinosaur reproductive behavior and social organization. The presence of such a high density of nests in specific sedimentary environments highlights the region's importance as a world-class paleontological site for studying the final chapters of dinosaur history in South Asia.

191. (B) The presence of early life (cyanobacteria) in shallow marine environments.
Stromatolites found in the Vindhyan Supergroup are significant evidence for early life on Earth. These layered structures were formed by the activity of cyanobacteria in ancient shallow marine environments during the Proterozoic

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essential for the sustainable development of the region.

221. (A) During the Proterozoic eon, before the Cambrian explosion.
The Vindhyan Supergroup is largely devoid of complex multicellular life fossils because it was deposited during the Proterozoic Eon. This period predates the Cambrian explosion, when most major groups of complex animals first appeared in the fossil record. Life during the Proterozoic was primarily microbial, as evidenced by the abundant stromatolites found in the Vindhyan rocks. This makes the unit a valuable resource for studying the early environmental and biological conditions of the Earth before the rise of complex life.

222. (A) The Vindhyan Basin
The Panna diamond belt is geologically associated with the margins of the Vindhyan Basin. The diamonds are found in primary kimberlite pipes that intrude into the Vindhyan sedimentary rocks, as well as in secondary conglomerate layers within the basin itself. This specific geological setting is unique in India and demonstrates the complex intersection of ancient volcanic activity and stable sedimentary basin formation that allowed for the accumulation of these precious gemstones in the northern part of Madhya Pradesh.

223. (A) The construction of a series of large dams.
The construction of a series of large dams and reservoirs is a significant human-made threat to the natural flow and ecology of rivers like the Narmada. These engineering projects alter the river's natural hydrogeological regime, affecting sediment transport, water quality, and aquatic biodiversity. While they provide essential water and power, their long-term environmental impact requires careful management to ensure that the ecological health of these major rivers is maintained alongside the state's developmental and economic goals.

224. (A) Dinosaurs
The petrified wood at Ghughwa Fossil Park dates back to the late Cretaceous period, a time when dinosaurs still roamed the Earth. These plant fossils provide critical information about the terrestrial flora that coexisted with dinosaurs in central India. By studying these petrified remains, researchers can reconstruct the ancient tropical forests and environmental conditions that existed just before the end-Cretaceous mass extinction event, offering a rare biological record of the flora from the final age of the dinosaurs.

225. (A) The Narmada Graben and the Tapti Graben
The Satpura Range is a classic example of a horst, a block of land uplifted between two structural troughs or grabens. Specifically, it lies between the Narmada Graben to the north and the Tapti Graben to the south. This structural arrangement was formed by the tectonic forces that created the rift valleys. The elevation of the Satpura Range thus represents a significant feature of the extensional tectonics that have shaped the central Indian landscape over millions of years.

226. (B) Groundwater and hydrocarbons
Besides coal, the Gondwana sandstones in Madhya Pradesh are important potential sources of groundwater and hydrocarbons. The primary porosity and permeability of these sedimentary rocks make them capable of storing both water and organic fluids. While they are major aquifers for regional water supply, they are also being explored for coal-bed methane and other energy resources. This highlights the multi-faceted economic and industrial importance of the Gondwana sequence beyond its traditional role as a source of thermal coal.

227. (A) Regulating the local microclimate and providing a vital water source.
The Bhoj Wetland provides essential ecological and urban services to the city of Bhopal. It acts as a primary source of drinking water and helps regulate the local microclimate, providing cooling effects and enhancing the urban environment. As a Ramsar site, its preservation is critical for maintaining these vital services and supporting a rich variety of biodiversity within the city. Its role as both an infrastructure asset and an ecological haven makes it an irreplaceable part of the state capital.

228. (D) The records of crop yields from surrounding modern farms.
A geoarchaeological study of Bhimbetka focuses on the interaction between ancient humans and their geological environment. This involves

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analyzing the rock types of the shelters, the chemical composition of the pigments used in the paintings, and the stone tools found in stratified deposits. While these elements provide critical information about prehistoric life and culture, records of modern crop yields are unrelated to the archaeological and geological history of the site, which predates settled agriculture in the region by thousands of years.

229. (A) Paleontological remains
In Madhya Pradesh, a 'Fossil Park' is a legally protected area dedicated specifically to the conservation of paleontological remains. These sites, such as Ghughwa, protect fossilized evidence of ancient life, including petrified plants or dinosaur remains. The primary goal is to preserve these irreplaceably records of Earth's biological history for scientific research and public education. These parks serve as open-air museums that highlight the state's unique geodiversity and its role in understanding the evolution of life across different geological eras.

230. (A) The onset of the Deccan Traps volcanism
The Lameta Formation is geologically significant as it represents the environment of central India immediately before the onset of the Deccan Traps volcanism. As an infratrappean sequence, these sedimentary rocks were deposited in fluvial and lacustrine settings just before the massive flood basalt eruptions began. The fossils preserved within the Lameta beds, including dinosaur remains, provide a final record of the terrestrial ecosystems that were subsequently covered and transformed by the extensive lava flows of the late Cretaceous.

231. (A) Dimensional stone (granite)
The ancient granitic rocks of the Bundelkhand Gneissic Complex are a valuable source of dimensional stone. Because these Archaean rocks are dense, crystalline, and occur in massive outcrops, they can be quarried and polished for use in construction and ornamentation. This industry utilizes the state's oldest geological formations to provide high-quality granite for both domestic and international markets, demonstrating how the basement craton contributes to the modern industrial and economic landscape of northern Madhya Pradesh.

232. (A) Amarkantak plateau
The BALCO aluminum plant was initially established to process high-quality bauxite sourced from the nearby Amarkantak plateau in eastern Madhya Pradesh. This region contains extensive bauxite deposits formed by the deep weathering of parent rocks in a tropical climate. The proximity and quality of these reserves made the Amarkantak area a critical resource hub for the national aluminum industry, driving regional mining development and supporting large-scale metallurgical operations in the central Indian heartland for decades.

233. (A) Dug wells and borewells
Over-exploitation of groundwater in the hard-rock areas of Madhya Pradesh frequently leads to the failure of dug wells and borewells. Because these aquifers have limited storage capacity and rely on localized fracture systems, they can be rapidly depleted when extraction rates exceed natural recharge. This creates a precarious situation for rural agriculture and domestic water security. Managing these resources requires careful monitoring and the promotion of artificial recharge structures to sustain the water tables in these geologically challenging environments.

234. (B) Geoheritage site
Discovering a previously unknown rock painting in the Vindhyan range identifies a potential new geoheritage site. Such sites are valued for their significant combination of geological features and cultural or scientific importance. While they can contribute to larger designations like Geoparks, the site itself is primarily recognized as an irreplaceable part of the natural and human record. Protecting these new discoveries is essential for expanding our understanding of prehistoric cultures and their interaction with the state's diverse geological landscape.

235. (A) A unique assemblage of significant geological heritage.
Jabalpur's high prospect as India's first Geopark is driven by its exceptional geological and paleontological heritage. The area features world-unique Precambrian marble gorges at Bhedaghat and world-class dinosaur fossil sites in the Lameta Formation. This combination of spectacular geomorphological landforms and rare Mesozoic fossils provides a compelling

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justification for recognition under the Geopark framework. Such a designation would promote conservation, education, and sustainable geotourism, highlighting the state's prominent position on the global geological map.

236. (A) It did not continue to spread and develop into an ocean basin.
The Narmada-Tapti rift system is called a 'failed rift' because the rifting process that was pulling the Indian plate apart did not continue to the point of total separation. While it created deep tectonic troughs and allowed for significant volcanic activity, it never developed into a new oceanic spreading center. Instead, the rifting stalled, leaving behind the major graben structures that now define the regional topography and drainage patterns, serving as a significant feature in the study of intra-continental tectonics.

237. (A) Metamorphosed ultramafic rocks
Soapstone, or steatite, deposits in Madhya Pradesh are typically associated with the metamorphism of ancient ultramafic igneous rocks. These deposits are found in metamorphic belts like the Sausar and Bijawar groups. Soapstone is a soft, talc-rich rock with many industrial applications, including in the production of ceramics, paper, and cosmetics. The presence of these resources is a result of the state's complex history of ancient volcanic activity and subsequent high-pressure metamorphism that transformed primary minerals into valuable industrial ores.

238. (A) National and international attention, expertise, and funding.
Designating a wetland as a Ramsar site helps attract significant national and international attention and resources. This recognition places the site on a global list of important wetlands, making it a priority for conservation funding and scientific expertise. It encourages government and non-governmental organizations to implement management plans that promote biodiversity and sustainable use. For Madhya Pradesh, these designations have been vital for securing the support needed to protect and manage its diverse and ecologically critical waterbodies.

239. (A) Royal procession or a scene of courtly life.
The most famous painting from the Bagh Caves originally depicted a vibrant scene of a royal procession or courtly life. These murals were once as renowned as those at Ajanta for their artistic quality and historical detail. Unfortunately, due to the deterioration of the mud-plaster surface and the friable sandstone, much of this art has been lost to time. These paintings served as a vital record of the social and artistic excellence of the Gupta and Vakataka periods in central India.

240. (A) The past climate and environment of the region.
The fossil records at both Ghughwa and the Narmada Valley provide critical evidence for reconstructing the past climates and environments of Madhya Pradesh. Ghughwa's petrified plants illustrate the tropical forest ecosystems of the late Cretaceous, while the Narmada Valley's mammals and hominids reflect the fluctuating environments of the Pleistocene. Together, these paleontological remains allow scientists to trace the environmental changes that have occurred over millions of years, providing a comprehensive understanding of the state's long-term ecological history.

241. (A) Metamorphosed sediments and lavas, sometimes with mineral deposits
The Bijawar Group is a significant stratigraphic unit in Madhya Pradesh characterized by a sequence of metamorphosed sedimentary and volcanic rocks. Dating to the Proterozoic, these rocks often contain valuable minerals like iron ore and rock phosphate. Their presence reflects an ancient period of tectonic activity and sedimentation in a marine environment. The study of the Bijawar Group is essential for understanding the crustal evolution of the northern part of the state and for identifying potential areas for mineral exploration.

242. (A) Encourage scientific and sustainable mining while promoting value addition within the state.
Madhya Pradesh's mineral policy aims to balance the economic benefits of mining with environmental and social responsibility. It encourages the use of scientific methods to maximize resource recovery while minimizing environmental impact. A key goal is to promote value addition—processing raw minerals into finished goods—within the state to create jobs and boost the regional economy. This sustainable approach ensures that the state's mineral wealth

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271. (A) Highly metamorphosed and crystalline
The Archaean-age rocks of Madhya Pradesh are characterized by being highly metamorphosed and crystalline. These granites and gneisses have undergone intense pressure and temperature over billions of years, transforming their original minerals and textures. As part of the stable basement complex, they represent the ancient and durable foundation of the state. These rocks lack fossils but are scientifically significant for understanding the earliest stages of crustal formation and the tectonic assembly of the Indian subcontinent during the Earth's early history.

272. (A) Vindhyan Supergroup
The slate pencil industry in Mandsaur is based on the quarrying of specialized shale or slate from the Vindhyan Supergroup. These fine-grained sedimentary rocks can be split into thin, consistent layers suitable for manufacturing writing implements. The local occurrence of these specific rock types has supported a unique regional industry for decades. This demonstrates how specific units within the state's diverse stratigraphy can provide the raw materials for specialized industrial and educational products, contributing to the local economic identity.

273. (A) Monitor, assess, and manage the state's groundwater resources.
The primary role of state groundwater agencies is to monitor and manage the regional groundwater resources. This involves assessing the yield and quality of different aquifers, tracking water table fluctuations, and promoting sustainable management practices like artificial recharge. In a state with diverse geological provinces like Madhya Pradesh, this work is essential for ensuring water security for agriculture and domestic use. It helps prevent over-extraction and guides the development of policies to protect these vital and finite underground water systems.

274. (A) The slow process of weathering and exfoliation of sandstone.
A primary geological threat to the prehistoric art at Bhimbetka is the natural process of weathering and exfoliation. Over long periods, the surface layers of the sandstone can peel away due to temperature changes and moisture, potentially taking the ancient paintings with them. Managing this slow but steady natural deterioration is a key challenge for conservators. Protecting these unique records of human culture requires understanding the geological processes affecting the shelters and implementing strategies to mitigate their impact on the fragile rock art.

275. (A) Pleistocene
The fossil record of the Narmada Valley is exceptionally rich for the Pleistocene epoch. This period saw a diverse range of mammalian fauna, including ancient elephants and hippos, alongside early hominids like the Narmada Man. The fluvial sediments of the valley have preserved these remains in a clear chronological sequence, providing a world-class record of evolution and environmental change during this significant geological time. The Narmada Valley thus serves as a critical site for international research into Pleistocene biodiversity and human history.

276. (A) Stresses from the Indian plate's collision with the Eurasian plate.
Tectonic activity along the Narmada-Tapti zone is primarily driven by stresses within the Indian plate. As the Indian plate continues to push northward and collide with the Eurasian plate, these compressional forces generate intra-plate stresses. These stresses are periodically released along ancient zones of weakness like the Narmada-Son Lineament, leading to modern seismic events. Understanding these plate-scale dynamics is essential for assessing earthquake risks and explaining the ongoing geological activity within the otherwise stable central Indian shield.

277. (A) Chemical and biogenic precipitate in a shallow sea
The limestone in the Vindhyan Supergroup was formed primarily as a chemical and biogenic precipitate in an ancient, shallow marine environment. During the Proterozoic, minerals like calcium carbonate accumulated on the seafloor, often aided by the activity of microbial mats or stromatolites. Over millions of years, these deposits were compacted and lithified into thick sedimentary sequences. These limestone beds are now a vital economic resource for Madhya Pradesh, providing the essential raw material for the state's extensive cement manufacturing industry.

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250. (A) K-Pg extinction event that wiped out the dinosaurs.
The fossils at Ghughwa provide a detailed view of the flora that existed in central India just before the K-Pg extinction event. This global event, which occurred roughly sixty-five million years ago, led to the mass extinction of many life forms, most notably the dinosaurs. By studying the Ghughwa fossils, researchers can understand the terrestrial ecosystems that were flourishing at the end of the Cretaceous period and the environmental conditions that preceded this major turning point in Earth's biological history.

251. (A) Manganese Ore
The Sausar Group of rocks in the Chhindwara and Balaghat regions is world-renowned for its significant manganese ore deposits. These ancient metamorphic rocks host some of India's highest-quality manganese, which is essential for the iron and steel industry. The extraction of this mineral from major mines like Bharveli is a cornerstone of the regional economy and a critical part of the state's mineral production. The Sausar Group thus represents an essential stratigraphic unit for understanding the state's metallurgical and economic wealth.

252. (D) All of the above.
Thermal power plants in Singrauli are major economic drivers but pose significant environmental challenges. These include the massive depletion of local water resources for cooling, the generation of large amounts of fly ash, and significant greenhouse gas emissions. Additionally, noise pollution from turbines and machinery affects the local environment. Managing these impacts is critical for achieving a sustainable balance between energy production and environmental protection in one of India's most important industrial and mineral-rich regions.

253. (A) Natural hydrogeological regime and river flow patterns.
The construction of numerous dams and reservoirs in Madhya Pradesh has significantly altered the state's natural hydrogeological and fluvial patterns. While these projects provide essential water for irrigation and energy, they change how rivers flow, how sediments are transported, and how groundwater is recharged. This engineering of the landscape represents a major transformation of the state's natural water cycles, requiring integrated water management to balance human needs with the ecological health of the regional drainage systems.

254. (A) Minerals like ochre and hematite
The vibrant reddish and yellow colors of the Bhimbetka rock paintings were primarily derived from regional minerals like ochre and hematite. Prehistoric artists ground these iron-rich rocks into fine pigments and mixed them with water or animal fat. The use of these durable mineral pigments is a key factor in why the art has survived for thousands of years in the natural shelters. This illustrates how early humans utilized the state's diverse geological resources for artistic and cultural expression.

255. (A) Interpretation and education about the geological landscape
Geotourism is distinguished from general tourism by its strong focus on the interpretation and education of the geological landscape. It aims to provide visitors with an understanding of the Earth's history, processes, and features, such as fossils, canyons, and volcanic plateaus. By combining aesthetic appreciation with scientific learning, geotourism fosters environmental awareness and a sense of stewardship for the natural world. This educational component is essential for promoting the conservation of geodiversity while supporting sustainable regional development.

256. (A) Major unconformity and a significant time gap.
The boundary between the Deccan Traps and the underlying Lameta Formation represents a major unconformity, signifying a significant time gap in the geological record. This boundary marks the transition from a period of continental sedimentation to the onset of massive flood basalt eruptions. Understanding this contact is crucial for reconstructing the geological sequence and the environmental changes that occurred just before the volcanic activity that transformed the

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late Cretaceous dinosaurs in central India. This evidence highlights the international significance of the Narmada Valley for studying prehistoric terrestrial life and behavior.

285. (A) Developing signages to explain the geological features to visitors.
A key management strategy for a proposed Geopark at Bhedaghat would be developing educational signages and interpretations. These tools help visitors understand the scientific significance of the marble gorge and the fossils in the Lameta beds, fostering an appreciation for regional geodiversity. This educational focus is a core pillar of the Geopark model, which aims to combine conservation with public awareness. By making geological history accessible, the Geopark can promote responsible geotourism that supports both site protection and local economic development in the Jabalpur region.

286. (A) The Proterozoic era
The Narmada-Son Lineament is a fundamental crustal feature that has influenced the geological evolution of central India since the Proterozoic era. This ancient zone of weakness has repeatedly guided sedimentation patterns, intrusive volcanic activity, and tectonic movements for over a billion years. Its long-term influence demonstrates that major structural features can remain active and significantly shape the Earth's surface across different geological periods. The lineament remains a critical focus for geologists studying the assembly and ongoing dynamics of the Indian shield and the state's regional structural framework.

287. (A) Fireclay
Fireclay is a critical mineral used in the production of refractory bricks and ceramics, and it is mined in significant quantities in the Jabalpur-Katni region. This clay is highly valued for its ability to withstand extreme heat without deforming, making it essential for lining industrial furnaces and kilns. The regional geology provides the specific clay mineral deposits needed for these applications. This resource supports a specialized industrial sector in Madhya Pradesh, contributing to national industrial capacity and fulfilling critical demands for high-temperature manufacturing across various sectors.

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288. (A) Artificial wetlands can also develop significant biodiversity and ecological value.
Man-made waterbodies like Sirpur and Yashwant Sagar underscore that artificial wetlands can develop immense biodiversity and ecological importance. Over time, these engineered habitats provide essential services and support diverse wildlife, including migratory birds. Their designation as Ramsar sites acknowledges that human-modified landscapes can become internationally significant ecosystems. This highlights the need to protect and manage a wide range of waterbodies across Madhya Pradesh to sustain regional biodiversity and environmental health alongside human development and water resource management.

289. (A) Social and cultural life of prehistoric people
The themes depicted in the Bhimbetka rock art provide a vibrant record of the social and cultural life of prehistoric people. Images of hunting, communal dancing, and family scenes offer direct insight into their subsistence strategies, rituals, and community structures. These paintings serve as a visual narrative of human experience over millennia, allowing researchers to trace the development of social behaviors and cultural practices. This artistic record is a primary source for understanding the deep history and daily lives of early populations in the central Indian landscape.

290. (A) The protection of important geological features from degradation.
Geoconservation is the active protection of important geological and geomorphological features, processes, and sites from degradation. It is a central concept for Geoparks, which aim to preserve irreplaceable aspects of the Earth's history, such as fossils, unique landforms, and rock formations. By implementing conservation strategies, governments and communities can ensure that these scientifically and culturally significant sites remain intact for research, education, and future generations. Geoconservation fosters a deeper appreciation for geodiversity and its role in supporting the natural world and human heritage.

264. (A) Monastic retreats (Viharas) for Buddhist monks
The Bagh Caves were specifically designed to serve as Viharas, or monastic retreats and dwellings for Buddhist monks. These rock-cut monuments provided a quiet and protected environment for spiritual study and daily life. The design included assembly halls and individual cells carved directly into the sandstone cliffs. This site represents a significant historical example of how geological features were modified by humans to create dedicated spaces for religious and communal activities during the ancient period in central India.

265. (A) Geotourism and mythological lore
The Pandav Caves in Pachmarhi are a popular destination that combines significant geotourism appeal with deep-seated mythological lore. Carved into the regional sandstones, these shelters are traditionally linked to the exile of the Pandavas from the Mahabharata. From a geological perspective, they offer a clear view of the local sedimentary formations. This intersection of natural geological features and cultural mythology makes the site a unique attraction, highlighting how geological landscapes are often integrated into regional traditions and history.

266. (C) Statement I is incorrect, but Statement II is correct.
While often referred to as a single feature, the Narmada-Son Lineament is actually a broad and complex zone of parallel and en-echelon faults and shear zones. It is not a single simple fault line. This structural zone has a deep-seated influence on the Earth's crust, affecting regional tectonics and seismicity over hundreds of millions of years. Understanding this complexity is essential for geologists studying the assembly and ongoing tectonic stresses of the central Indian subcontinent.

267. (A) Refractory and ceramic industry
Fireclay deposits in the Jabalpur and Shahdol regions are essential for the refractory and ceramic industries. This specialized clay can withstand very high temperatures without melting, making it ideal for lining furnaces and manufacturing heat-resistant products. The regional geology provides the specific clay minerals needed for these industrial applications. The presence of these resources supports a dedicated industrial sector in Madhya Pradesh, contributing to the state's diverse mineral economy and fulfilling critical demands for national industrial infrastructure.

268. (A) The Shipra River
The ancient city of Ujjain is situated on the banks of the Shipra River. This location is not only religiously significant for the Kumbh Mela and the Mahakaleshwar temple but also historically important for its role as a center for astronomical study. The river's path is influenced by the regional topography of the Malwa plateau. The integration of the river with the city's religious and scientific heritage highlights the long-standing importance of hydrogeological features in shaping the cultural and historical geography of Madhya Pradesh.

269. (A) All of the above
Studying rock art at sites like Bhimbetka requires a multi-disciplinary approach. Archaeologists examine the artifacts and layers within the shelters, while geologists analyze the host rock and weathering processes. Chemists study the composition of the ancient pigments to understand how they have survived. Anthropologists and art historians provide cultural context and stylistic analysis. Together, these diverse scientific and humanities fields offer a comprehensive understanding of the deep human history and artistic evolution preserved within the geological landscape.

270. (A) A designated route that guides visitors through a series of interesting geological sites
A geotrail is a specially curated route designed to guide visitors through a sequence of geologically significant sites. It often includes educational signages and interpretations to help travelers understand the rocks, landforms, and fossils they are seeing. Developing geotrails is a key prospect for promoting geotourism in Madhya Pradesh, as it allows for a structured and educational way to explore the state's diverse geodiversity while supporting regional conservation efforts and providing economic benefits to local communities.

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leverages its geological advantages to support national energy and infrastructure needs. This mineral-based economy is a fundamental part of the state's identity and provides a solid foundation for regional industrial development and social progress.

298. (A) Man-made ancient hydrogeological structures to access groundwater

Step-wells, or baolis, are sophisticated man-made ancient structures designed to provide reliable access to groundwater. They feature multi-story stone architectures with steps leading down to the water table. These wells were essential for urban and rural survival in regions with seasonal rainfall. They represent an advanced understanding of regional hydrogeology and represent a vital part of the state's cultural and engineering heritage. Baolis provided not only water but also community spaces and religious sites, showcasing how historical societies integrated water management into their social and architectural landscape.

299. (A) The growth of lichen and micro-organisms on the rock surface.

A significant threat to the physical integrity of rock art is the growth of lichen and other micro-organisms on the rock surface. These biological organisms can penetrate the rock and the ancient pigments, causing physical and chemical damage. Over time, they can obscure the art and lead to the exfoliation of the surface layer. Managing this threat is a critical task for conservators, requiring specialized techniques to clean the rock surfaces without damaging the fragile prehistoric paintings, ensuring their long-term preservation within the state's natural shelters.

300. (B) The Indian Plate

The entire geodiversity of Madhya Pradesh is a record of the state's long journey as a core part of the Indian Plate. From its ancient Archaean foundations to its sedimentary basins and volcanic plateaus, each feature reflects the tectonic movements and environmental changes the plate has experienced over billions of years. This geological history provides the context for the state's mineral wealth, landscapes, and heritage. Understanding Madhya Pradesh as part of the broader Indian Plate is essential for reconstructing the assembly and evolution of the entire Indian subcontinent.

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278. (A) Large tank or 'sagar' created by building an earthen dam
In the Bundelkhand region, a common man-made ancient waterbody is a large tank, often called a 'sagar.' These were created by building earthen dams across seasonal drainage channels to harvest and store monsoon rainfall. These structures are vital for local water security, helping to recharge groundwater in the hard-rock landscape. They represent a significant aspect of regional hydro-heritage, illustrating how historical communities engineered the local topography to adapt to the specific geological and climatic challenges of central India.

279. (A) They represent a rare example of rock-cut architecture and Gupta-era painting in Central India.
The Bagh Caves are significant because they serve as a rare and outstanding example of rock-cut architecture and murals from the Gupta era in Central India. While many caves have suffered damage, the remaining fragments provide invaluable evidence of ancient Buddhist life, artistic skill, and engineering. They represent a historical peak of creative excellence where regional geology was transformed into enduring spiritual monuments. Their preservation is essential for understanding the cultural and artistic evolution of the subcontinent during one of its most influential historical periods.

280. (A) Petrified tree trunks lying in the positions they were found
Visitors to the Ghughwa Fossil Park can see extraordinary petrified tree trunks exactly where they were discovered. This 'in-situ' display provides a clear view of the ancient forests that once covered central India sixty-five million years ago. These stone fossils preserve the original growth positions and textures of the trees, offering a unique and educational experience. The park serves as an open-air museum that highlights the state's rich paleobotanical heritage and provides a tangible connection to the terrestrial ecosystems of the late Cretaceous period.

281. (A) Bhander Group of the Vindhyan Supergroup
The Bhimbetka rock shelters are carved into the sandstone of the Bhander Group, which is part of the Proterozoic Vindhyan Supergroup. This specific geological unit consists of durable, fine-grained sandstone that occurs in thick, horizontally bedded sequences. The nature of this rock allowed for the formation of natural shelters and provided a stable, smooth surface for prehistoric artists to create their rock art. The Bhander Group thus forms the fundamental geological foundation for this internationally significant archaeological and cultural heritage site in Madhya Pradesh.

282. (A) Fly ash
Fly ash is a major byproduct of the coal-fired thermal power plants in Singrauli. Large volumes are generated daily from the combustion of Gondwana coal. Recently, there has been a significant push to use this fly ash in industrial applications, such as in the manufacturing of bricks and as an additive in cement. Utilizing this byproduct helps manage environmental pollution while providing a valuable resource for the construction sector, demonstrating how industrial waste can be converted into useful materials within the state's mineral-based economy.

283. (A) The network of joints, fractures, and bedding planes
In the 'Vindhyan Province,' groundwater potential is primarily controlled by the network of joints, fractures, and bedding planes within the sedimentary rocks. These secondary features provide the necessary space for water to accumulate and flow through otherwise dense sandstone and limestone layers. While the rocks have low primary porosity, these structural weaknesses create localized aquifers that are essential for regional water supply. Managing groundwater in this province requires a detailed understanding of these structural controls to ensure sustainable extraction and effective resource planning.

284. (A) Herding and nesting behavior
The discovery of numerous clutches of Titanosaurus eggs in the Lameta Formation provides compelling evidence for dinosaur herding and nesting behavior. The high density of nests in specific areas suggests that these dinosaurs returned to the same locations to breed, similar to some modern reptiles and birds. These paleontological finds offer a rare glimpse into the social lives and reproductive strategies of

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is managed as a long-term asset that supports industrial growth and social development for its people.

243. (A) Different types of groundwater provinces based on geology.
A hydrogeological map of Madhya Pradesh uses different colors to represent various groundwater provinces defined by their underlying geology. For example, areas with porous Gondwana sandstones, fractured Deccan basalts, or dense crystalline basement rocks are mapped separately. This visual representation helps water managers and scientists understand the varying potential and behavior of groundwater across the state. It is an essential tool for planning sustainable water extraction, managing recharge projects, and identifying regions most vulnerable to water scarcity or contamination.

244. (A) Cave No. 4 (Rang Mahal)
The most famous of the Bagh Caves is Cave Number 4, popularly known as the 'Rang Mahal' or Palace of Colors. This cave was renowned for its elaborate murals and frescoes that decorated its walls and ceilings. Although much of the original art has deteriorated, the surviving fragments and historical records highlight its significance as a peak of Buddhist artistic achievement. It represents a critical site where geological craftsmanship and historical artistic excellence meet within the state's diverse geoarchaeological heritage.

245. (A) Calcium Carbonate (Calcite/Dolomite)
Chemically, the marble rocks at Bhedaghat are primarily composed of calcium carbonate, existing as the minerals calcite or dolomite. These rocks were originally sedimentary limestones that underwent high-grade metamorphism, transforming them into the durable and crystalline marble seen today. Their chemical composition dictates their white and varied colors and their resistance to erosion, allowing the Narmada River to carve the deep, stunning gorge that makes the site a world-famous destination for both geologists and tourists in central India.

246. (A) The Himalayas are a result of compression, while the Narmada Valley is a result of tension.
A fundamental difference in tectonic setting exists between the Himalayas and the Narmada Valley. The Himalayas were formed by the intense compressional forces of the Indian plate colliding with the Eurasian plate, leading to massive uplift and folding. In contrast, the Narmada Valley is a result of tensional or extensional forces within the Indian plate that pulled the crust apart, creating a down-dropped rift valley or graben. These different forces reflect the varied tectonic processes that have shaped the Indian subcontinent.

247. (C) Vindhyan Supergroup
Ochre deposits in the Satna region are geologically associated with the Vindhyan Supergroup. These earthy mineral pigments were formed by the weathering and oxidation of iron-rich sedimentary layers within the Proterozoic sequence. Ochre has been historically and industrially important for the production of paints and dyes. Its occurrence in the Vindhyan rocks illustrates how long-term geological processes can transform primary sediments into valuable industrial minerals that support local manufacturing and traditional arts across the state.

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248. (A) Traditional rainwater harvesting and groundwater recharge structures.
Many of the tanks and ponds in the Bundelkhand region serve as traditional rainwater harvesting and groundwater recharge structures. These man-made features were engineered to capture monsoon runoff, providing a vital source of surface water while also allowing for the slow infiltration of water into the local aquifers. They represent a significant aspect of the state's hydrogeological heritage, showing how past societies developed sustainable ways to manage water in a region with challenging geological and climatic conditions.

249. (A) Geo-archaeological heritage and deep human history of the region.
Bhimbetka, the Bagh Caves, and the Narmada Valley are all vital sites for understanding the geo-archaeological heritage of Madhya Pradesh. Together, they provide a record of deep human history, from the evolution of early ancestors and the development of stone tools to the creation of prehistoric art and rock-cut architecture. These sites illustrate how the state's diverse geological landscape has provided shelter, materials, and

291. (A) The area has experienced tectonic activity after the eruption of the lavas
While the Deccan Traps are generally flat-lying, the presence of tilted or faulted flows in the Narmada Valley indicates that the area experienced significant tectonic activity after the volcanic eruptions. These structural disturbances show that ancient faults in the rift zone were reactivated, deforming the thick basaltic sequence. Studying these features allows geologists to reconstruct the tectonic history of central India and understand how internal crustal stresses have continued to shape the region's topography and drainage patterns long after the massive volcanic events concluded.

292. (A) Value addition through cutting, polishing, and manufacturing
Government-supported 'Diamond Parks' and special zones aim to promote value addition within the gemstone industry. Instead of only mining raw stones, these zones focus on the cutting, polishing, and manufacturing of finished jewelry. This strategy aims to create skilled jobs and boost the regional economy by capturing more of the value chain within Madhya Pradesh. It leverages the state's unique position as India's primary diamond source to build a sophisticated industrial sector that contributes to national exports and regional economic growth.

293. (A) Promoting uncontrolled urban development on the shorelines.
A management plan for a Ramsar site focuses on conservation and 'wise use,' which specifically excludes promoting uncontrolled urban development. Instead, these plans prioritize the monitoring of water quality and wildlife populations, such as migratory birds. They include awareness programs for local communities and measures to control invasive species. The goal is to ensure that the wetland's ecological integrity is maintained while supporting sustainable human activities. Promoting shoreline development would contradict the primary objective of protecting these internationally significant habitats and their essential ecosystem services.

294. (A) The archaeology of South Asia.
The long-term record of human occupation at Bhimbetka makes it a benchmark site for the archaeology of South Asia. It provides a rare and continuous stratified record that spans from the Paleolithic through the Mesolithic and into the historic period. This sequence allows researchers to study the evolution of human technology, cultural practices, and social organization in a single geographical location over tens of thousands of years. Its significance lies in providing a deep historical context for the development of human societies within the Indian subcontinent.

295. (A) Fluvial (river-deposited) gravels and clays
Fossils in the Narmada Valley are primarily found within fluvial sediments, such as ancient river gravels and clays. These deposits were accumulated by the ancestral Narmada River over millions of years, trapping and preserving the remains of mammals, hominids, and other fauna. The burial of these remains in river-deposited material protected them from rapid decay and environmental destruction. Studying these fluvial sequences is essential for reconstructing the prehistoric environments and understanding the biodiversity and evolutionary history of central India through the fossil record.

296. (A) The tectonic forces that created the Narmada and Tapti rifts.
The general east-west alignment of the Satpura Range is a direct result of the tectonic forces that created the Narmada and Tapti rift valleys. These extensional forces fractured the Earth's crust into parallel blocks, some of which dropped down to form valleys while others were uplifted to form mountain ranges. This structural arrangement, with the Satpura Range acting as an elevated horst between two grabens, has dictated the regional topography and drainage patterns. It reflects the dominant role of rift-related tectonics in shaping the central Indian landscape.

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297. (A) Resource-processing and mineral-based industries
Madhya Pradesh's diverse mineral wealth, including coal, limestone, and copper, makes its industrial landscape heavily dominated by resource-processing and mineral-based industries. These sectors, such as cement manufacturing, thermal power generation, and metallurgical refining, directly utilize the state's natural resources to drive economic growth. The state's strategic focus on these industries

central Indian landscape, highlighting a dramatic shift in the region's geological processes.

257. (A) Jhabua
Jhabua is the primary district in Madhya Pradesh for the mining of rock phosphate, an essential ingredient for the production of chemical fertilizers. These deposits are associated with ancient sedimentary and metamorphic rocks. The mining of this mineral is critical for supporting the national agricultural sector by providing the necessary nutrients for soil fertility and crop production. The regional geology of Jhabua thus plays a vital role in the broader industrial and agricultural framework of the country.

258. (A) Serving as habitat for migratory and resident waterfowl
A critical ecological service provided by the wetlands of Madhya Pradesh is serving as a vital habitat for migratory and resident waterfowl. This importance led to the recognition of sites like the Bhoj Wetland and Sirpur Lake as Ramsar sites. These wetlands support rich biodiversity, providing food and nesting grounds for birds traveling long distances. Their conservation is essential for maintaining global bird populations and ensuring the ecological health of regional ecosystems within the state's diverse landscape.

259. (A) The age of the art, with Bhimbetka being thousands of years older.
A major difference between these two sites is the age of the art. Bhimbetka features rock paintings that date back thousands of years to the prehistoric era, including the Paleolithic and Mesolithic. In contrast, the murals at the Bagh Caves are significantly younger, dating to the Gupta and Vakataka periods of the fourth to sixth centuries AD. This chronological distinction reflects the long and varied history of human artistic expression preserved within the geological features of Madhya Pradesh.

260. (A) World-class paleontological research area
Discovering nearly complete dinosaur skeletons in the Narmada Valley highlights the region's potential as a world-class paleontological research area. These finds provide invaluable evidence for understanding the diversity and evolution of Mesozoic terrestrial life in South Asia. The exceptional preservation of these fossils allows scientists to conduct detailed studies on dinosaur biology and prehistoric environments. This underscores the international significance of Madhya Pradesh's geological formations for advancing our knowledge of the Earth's past life and ecosystems.

261. (A) Cement-grade limestone and building stone
The Bhander Group, the uppermost unit of the Vindhyan Supergroup, is a major source of high-quality limestone and durable building stones. The limestone is essential for the flourishing cement industry in northern Madhya Pradesh, while the sandstones are widely used across India for construction and ornamentation. The accessible and horizontally bedded nature of these rocks makes them ideal for large-scale extraction, supporting the state's role as a primary provider of essential building materials for national infrastructure.

262. (A) Locally quarried rock, often basalt or granite
Numerous small-scale 'stone crushers' across Madhya Pradesh utilize locally quarried rocks, primarily basalt from the Deccan Traps or granite from the basement complex. These rocks are crushed into aggregate for use in road construction and building foundations. This mineral-based industry is a direct consequence of the widespread availability of durable crystalline and volcanic rocks throughout the state. It provides essential materials for regional infrastructure development while creating local employment in the construction and quarrying sectors.

263. (A) High surface runoff and groundwater storage in fractures.
The low primary permeability of the Deccan Basalt leads to high surface runoff during the monsoon, as water cannot easily penetrate the dense rock. Consequently, groundwater storage is restricted to secondary features like tectonic fractures and weathered zones. This hydrogeological setting makes groundwater extraction challenging and unpredictable, as successful wells must intersect these localized storage systems. Managing water in these areas requires a scientific understanding of the basaltic landscape to ensure reliable and sustainable regional water supplies.

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